The Polynemid Fishes of India

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THE POLYNEMID FISHES OF INDIA

By

P.V. Kagwade

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CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

Marine Fisheries P.O.

Mandapam Camp

Ramanathapuram District

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THE BULLETIN OF THE CENTRAL MARINE FISHERIES RESEARCH INSTITUTE IS PUBLISHED AT IRREGULAR INTERVALS AS AND WHEN INFORMATION OF A GENERAL NATURE BECOMES AVAILABLE FOR DISSEMINATION.

C O N T E N T S

FOREWORD

Members of the family Polynemidae, popularly known as thread-fins, a name derived from the presence of several slender filaments on the lower part of the pectoral fin, are tropical and sub-tropical species contributing to the fisheries of regional importance. In the world polynemid fisheries, India ranks very high. The importance of the fishery lies mostly in the high quality table fishes like 'Dara', Polynemus indicus, and 'Rawas', Eleutheronema tetradactylum both of which grow to fairly large size of over a metre in length and obtained in appreciable quantities on the north western coasts of India. Over the past one decade or more, the polynemid landings have declined considerably in India and other parts of the world, but the reasons for their decline are little understood. The fishery biology of this group of fishes has, in the past received very little attention. Dr. (Mrs.) P.V. Kagwade who had very painstakingly devoted attention to studies on this group during the past fifteen years at this Institute has presented in this Bulletin a clear and comprehensive account of aspects of biology and fishery of the polynemid species so far known from the Indian coasts. I place on record my high appreciation and offer my sincere thanks to Mrs. Kagwade for this very useful reference work on the subject. My thanks are also due to all those who are responsible for bringing out this publication. As in the case of other numbers of the Bulletin of this Institute, it is hoped that this too will be welcomed by all interested in the subject.

Dr. R.V. NAIR
Director
Central Marine Fisheries
Research Institute

Mandapam Camp
1st June 1970

I INTRODUCTION

Polynemids are among the most highly esteemed table fishes, especially the larger species like Eleutheronema tetradactylum and Polynemus indicus. They occur all along the east and the west coasts and support fisheries of some importance throughout the year, though peak landings are restricted to certain periods of definite duration in regions especially on the northwestern coast of India where they are most abundant. Being migratory fishes, at least some of the species, occur not only in the sea but also in the river-mouths and estuaries. Species like P. indicus and P. heptadactylus, the habits and habitats of which have been studied in greater detail than others, are known now to support not only the inshore fisheries but also the offshore catches by trawlers from depths upto about 70 metres. The recent exploratory surveys have brought into prominence this hitherto little known resource from the deeper grounds which come to be exploited now regularly by the commercial trawlers. Their being favoured as extremely good eating fishes with wide seasonal and spatial distribution range, this group of fishes comprises a resource which plays an important role in the national economy. Among the world production of polynemids, even in the present declining years, for some nominal species as P. indicus, India's annual landings occupy the first two or three ranks.

The family polynemidae is widely distributed in the tropical parts of the Atlantic, Indian and Pacific Oceans and is not so far known to occur in the Red Sea (Fig. 1). Members of this family are recorded from the eastern tropical Pacific Ocean from the upper portion of the Gulf of California to Northern Peru (Klawe and Alverson, 1964). Some polynemids occur in the Atlantic Ocean off the Gold Coast (Irvine, 1947). It is known that polynemids inhabit the Indian Ocean from the coasts of South

Africa, Madagascar, Mauritius, Pakistan, Indian Peninsula, Andamans, Burma and Singapore. They are recorded from the Indonesian and adjacent islands, north Borneo, Celebes, Philippines, New Guinea and Australia in the Indo-Pacific waters. They are found in the western part of the Pacific Ocean, in Japan, Formosa, Hong Kong and in a number of islands of Fiji, Samoa, Hawaiian gr. and Marquesas. Though widely distributed, they show greater concentration in the Indo-Pacific region.

The family Polynemidae is classified by Day under Polynemiformes of the order Acanthopterygii; Weber and de Beaufort (1922) have treated it under the order Percesoces; Jordan (1923), Irvine (1947) and Herre (1953) included it under the order Mugiloidea. The group Polynemiformes of Day has been raised to the rank of an order by Berg (1940), Mendis (1954) and Munro (1955 & '58). The orders Percesoces, Percomorphi or Mugiloidea are synonymous. Based on the presence or absence of free pectoral filaments, position of the eyes and the number of spines in the first dorsal, this order is divided into families. Polynemidae is distinguished from all other families under the order by the presence of a varying number of free pectoral filaments articulating with a bone formed by the union of pterygials and anchylosed with the scapular and coracoid bones.

Day included all the polynemids under a single genus Polynemus whereas Weber and de Beaufort, Mendis and Munro grouped them under two genera, namely, Eleutheronema and Polynemus. Misra (1959) separated the polynemids under the generic heads, Eleutheronema, Polydactylus Lacepede 1803 and Polynemus. Meyers (1936) tentatively regarded Eleutheronema, Polydactylus and Polynemus along with four others, viz., Polistonemus Gill, Pentanemus Gunther, Galeoides Gunther and Filimanus Meyers as valid genera of the family Polynemidae.

The family Polynemidae as described by Day (1878) has the following characters: seven branchiostegals, oblong body which is somewhat compressed; eyes large, lateral and more or less covered by adipose lids; mouth ventral to a prominent snout and having a lateral cleft, villiform teeth on jaws, palatines and sometimes on vomer; two distinctly separated dorsal fins, first with seven to eight spines and the second

Fig. 1. Geographical distribution of Polynemids. Solid circles indicate recorded distribution.

a spine and
with eleven to sixteen rays; several mobile articulated tactile filaments below the pectoral fins; ventrals thoracic, with one spine and five rays; caudal fin deeply forked; scales ctenoid or cycloid on head and body, minute scales sometimes on second dorsal, anal, ventral and caudal; lateral line continuous and continued on to the caudal fin; muciferous system on the head well developed; vertebrae twenty-four; air bladder when present varying in form and structure.

Weber and de Beaufort (1922) and Munro (1955) used the following salient features to distinguish the genera under this family: Eleutheronema is characterised by the lower lip being developed only at the corner of the mouth, teeth extending to the exterior part of the jaws and the number of pectoral filaments being either three or four; Polynemus has the lower lip well developed, but not continued to symphysis, teeth in jaws not extending to the exterior and pectoral filaments five or more. Meyers (1936) states that in Polydactylus the lateral line is straight; the pectoral fin is inserted low, the upper part of its base being situated much below the mid-lateral line of the body; lower lip extends far forward; teeth are absent on the outer side of the jaws, maxillaries are distinctly widened at the ends and a sharp pectoral fold is present extending to the base of one or more pectoral filaments, the number of which is variable whereas in Polynemus the anterior part of the lateral line rises in a long low curve; the sharp pectoral fin is inserted high; pectoral fold is absent and the number of pectoral filaments is seven with no air bladder. The recognition of Polydactylus Lacepede as a valid genus is still controversial and Meyer's definition of the characters as referred above are tentative. However, in the present work Polydactylus (as defined by Meyers, (loc. cit.)) is considered synonymous with Polynemus Linnaeus. In the following account a tentative key to the identification of the Indian genera and species of polynemids so far known is given.

SYNOPSIS OF GENERA

I. Lower lip absent except at the corners of the mouth, teeth extending on to the exterior part of the jaws, free pectoral filaments not more than four ... Eleutheronema

II. Lower lip well developed and extending forward but not to symphysis, teeth not extending to exterior part of jaws, free pectoral filaments five or more ... Polynemus

SYNOPSIS OF SPECIES OF ELEUTHERONEMA

1. Four free pectoral filaments ... E. tetradactylum

SYNOPSIS OF SPECIES OF POLYNEMUS

1. Five free pectoral filaments

   A. Free pectoral filaments reaching to the end of ventral fin, pectoral rays undivided; vomerine teeth present; L.l. 60-65 ... P. plebeius

   B. Free pectoral filaments reaching the middle of ventrals; a dark opercular spot and a dark shoulder blotch at the beginning of the lateral line; L.l. 47-50 ... P. microstoma

   C. Free pectoral filaments reaching to about anal fin, pectoral rays some divided and others undivided; vertical fins dark edged; L.l. 70-75 ... P. indicus

2. Six free pectoral filaments

   A. Free pectoral filaments extending upto middle or end of the ventral fin, pectoral rays mostly divided; vomerine teeth absent; shoulder blotch present; L.l. 48-50 ... P. sextarius

   B. Free pectoral rays extending beyond the ventral fin

      (a) Pectoral fin black, dorsal and anal fins black edged; no shoulder blotch; large air bladder; L.l. 46. ... P. sexfilis

      (b) Fins edged black; no shoulder blotch; air bladder absent ... P. xanthonemus

3. Seven free pectoral filaments

   A. Free pectoral filaments very long, the first three twice as long as the body; L.l. 70 ... P. paradiseus

   B. Free pectoral filaments extending to about the end of the ventrals, pectoral rays unbranched; L.l. 48-50 ... P. heptadactylus

II POLYNEMUS INDICUS SHAW

IDENTITY

Common names

India	Marathi	...	Dara, Chelna
	Malayalam	...	Yeta
	Tamil	...	Tahlunkala
Burma	Arraccanese	...	Lukwah
	Burmese	...	Katha or Kakuyan
Thailand	Tavoy	...	Kweyyeng

Synonyms

Polynemus indicus Shaw 1804
Cantor 1850
Bleeker 1854
Gunther 1860
Kner 1865-1867
Day 1878-1888
Vinciguerra 1889-1890
Weber and de Beaufort 1922
Herre 1936
Mendis 1954
Munro 1955

Polynemus sele Hamilton & Buchanan 1822

Polynemus uronemus Cuvier and Valenciennes 1829
Bleeker 1849

Trichidion indicum Bleeker (1867) 1868

Trichidion indicus Fowler 1905

Polydactylus indicus Fowler 1938, 1949
Smith 1953
Misra 1959

Description

D^1. VIII; D^2. I, 13-14; P. 2-3. 12+5; V. 1,5; A. II-III, 11-12; L.l. 70-75; L.tr. $\frac{7}{1}$ $\frac{}{12\text{-}13}$.

Length of the head 4¼ to 4½ and height of the body 6 times in total length; diameter of the eyes 1/7 of length of head (Fig. 2). Snout pointed, maxillaries scaly and twice in head. Teeth villiform in jaws, broader bands of teeth on palatines and a rounded patch of teeth on the vomer. Pectoral falciform, 2-3 pectoral rays simple and the remaining branched; first free filament the longest reaching beyond tip of ventrals or even anals. Dorsals, anal and caudal scaly. Caudal deeply forked with long pointed lobes which are usually prolonged into filaments, the lower being mostly the longer. Air-bladder large. Lateral line continued almost to the end of the lower caudal lobe. Back purplish and dark, abdomen yellowish white.

DISTRIBUTION

Madagascar, Mauritius, India, Burma, Ceylon, Penang, Malacca, Australia and Society Islands.

Differential distribution

Eggs and larvae:- Eggs and larvae of P. indicus were observed in plankton of the offshore area about 25 miles north-east of Madras harbour (Kuthalingam, 1960).

Juveniles:- The nursery grounds of juvenile P. indicus appear to be off Dwarka (Nayak, 1959a) where the fishery is good. Stray individuals, some of which are very small in size to the minimum of 5.6 cm in furcal length are also encountered in Bombay waters (Nayak, 1959a). Kuthalingam (1960) has stated that this species uses the inshore waters as nursery for its young in Madras coast.

Adults:- P. indicus in the adult stage are found in abundance off Gulf of Cambay and Gulf of Kutch. The season in the former extends from December to May with the peak during March-May and in the latter from February to May (Deshpande, 1962). This species begins to enter Madras

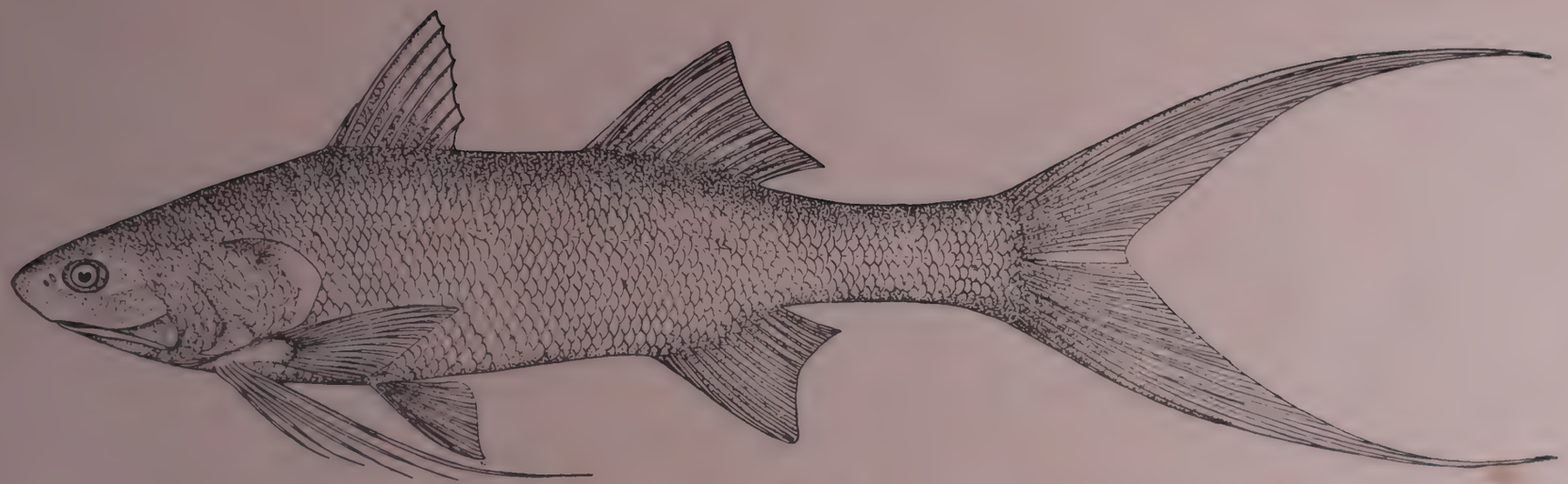

Fig. 2. ***Polynemus indicus*** Shaw, Juvenile × 5/6.

waters in December and disappear by March (Kuthalingam, 1960).

Behaviouristic and ecological determinants of the general limits of distribution:- The partly pelagic and partly demersal, polynemid fishes are generally found in the coastal waters. They move in small schools and are found in deeper as well as shallower waters. Most of them are highly tolerant to great changes in salinity and this is evidenced by their entering estuaries and even lagoons. Their movement towards the coast and estuaries from the far out sea appears to be for the purpose of breeding. The coastal waters within 20-30 nautical miles from the shore serve as a the nursery grounds for the young, for feeding and rapid growth.

P. indicus, though tolerant to salinity changes, is not known to enter the rivers. However, it enters the bays and the gulfs. Though no direct relationship of its catch with the salinity is available, it can be suggested from the findings of Jayaraman and Gogate (1957) on the salinity values of the Arabian Sea from 20° N, 22° N and 23° N latitudes, the zones where this species is found in abundance, that it tolerates high salinity of 35 °/oo to 37 °/oo. It occurs in abundance in shallower waters. Deshpande (1962) states that it prefers turbid water, sea bottom with soft mud and rocky areas. Jayaraman et al (1959) have noted that it prefers temperature below 24°C and moves to deeper water zones with the increase in temperature. It is abundant in the offshore waters during the neap tide period and in the inshore waters during the spring tide period. It is a voracious and predatory fish.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality:- Till the recent past polynemids were known to be unisexual like the majority of Actinopterigiian fishes. Now it is known that to a large extent they fall in line with some of the members of the families like Maenidae, Sparidae and Serranidae which are normally hermaphrodite. Since the last decade, examination of most of the polynemid species has shown hermaphrodite individuals in addition to the usual males and females. The species to be mentioned in this connection are

P. heptadactylus (Nayak, 1959b and Kagwade, 1968c), Pentanemus quinquarius and Galeoides decadactylus (Longhurst, 1965), E. tetradactylum (Patnaik, 1967), P. sextarius, P. sextarius var. mullani, P. xanthonemus and P. plebeius (Hida, 1967) and P. indicus (Kagwade, 1969a). The structure of the ovotestis in all these species happens to be the same, the ovarian and testicular parts of each of the ovotestis running end to end from anterior to posterior, the former being placed on the outer side towards the body-wall and the latter facing each other on the inner side. In all the species, individual variations are met with in regard to the extent of areas occupied by each of the sex elements.

The sexes in P. indicus are found to be separate, but sometimes, they are combined, exhibiting hermaphrodite condition (Kagwade, 1969a). Sections of an ovotestis of a specimen measuring 92.5 mm in furcal length showed immature ova of about 0.08 mm in the ovarian part and the male sexual elements in the various stages of spermatogenesis with some fully formed sperms scattered in bundles in the testicular part. The author has noticed that in ovotestis of individual fishes the size of the testicular part varies a great deal but is either equal to or smaller than the ovarian part.

Maturation:- The maturity of P. indicus is discussed in some detail by Nayak (1959a) and Karekar and Bal (1960). The ova invisible to the naked eye of the immature ovaries, measure up to 0.30 mm in diameter; the yellow and opaque ova in the enlarging and maturing ovaries measure between 0.31 to 0.62 mm and the mature transparent ova in the full creamish ovaries measure from 0.63 to 1.10 mm (Table 1). The polynemid eggs are pelagic and the oil globules in the mature ova of this species measure from 0.15 to 0.30 mm in diameter. It may be pointed out here that Kuthalingam (1960) from planktonic collections reported fertilized eggs of P. indicus measuring on an average 1.3 mm with an oil globule of 0.5 mm in diameter.

Size at first sexual maturity:- The size at first sexual maturity for P. indicus is about 80 cm in standard length (Karekar and Bal, 1960). The maximum size of this fish on record is 142 cm (Mohamed, 1955) and the fish thus is supposed to attain maturity when it grows to over half this length (Table 2).

Fecundity:- It is well known that fecundity increases with the length of fish. In fishes like polynemids which spawn in several batches, it is rather difficult to estimate the number of ova forming a season's crop. No information is available on the number of batches in which each fish liberates the eggs and the number of ova in each batch forming a season's crop. In the case of P. indicus Karekar and Bal (1960) have found that amongst the individuals of the same length, the estimated ova varied widely indicating the possibility of the spawning taking place in several batches.

From the frequency polygons of the ova diameter from the ovaries in stage V of maturity, Karekar and Bal (1960) suggest that in P. indicus during the spawning season at least three batches of ova mature in succession and the ova in each of these batches may vary between 2,550 and 4,000 per gram sample; fishes with less than 2,550 ova are supposed not to spawn in the same season but in the next. However, it is doubted whether the number of ova in a gram sample can be related to the ova in different batches. Table 3 shows how the estimated ova differ for the same length of fish in P. indicus. The highest of 5,611,650 ova for the fish length of 79 cm in this species has been recorded by Karekar and Bal (1960).

Spawning:- The polynemid species so far studied show that in general, the spawning is continuous all round the year. This is proved by the presence of immature, maturing, mature and spent individuals simultaneously during any part of the year. In some cases it is also supported by the occurrence of larvae and post-larvae throughout the year. However, each of these species revealed its own peak spawning period and frequency of spawning.

Nayak (1959a) has found April-June and October-December as the two peak spawning periods for P. indicus from the Bombay waters; studies by Kuthalingam (1960) have revealed intensive breeding in this species during October-November in the inshore waters of Madras (Table 4). Of the two peak spawning periods mentioned by Nayak, April-June period is found to be the major one.

Spawning appears to be continuous for the species as a whole,

because there are two prolonged periods of spawning and in each period the eggs are liberated in spurts and not all at one time.

Spawning grounds:- With some exceptions, most of the polynemids move towards the coastal waters for breeding. The juveniles of P. indicus up to the size of 90 cm are found in abundance in the nursery ground of the shallower waters of Dwarka region. The adults from the deeper waters move towards the coast in the north western part of this country and enter the gulf for breeding. Specimens in roe are obtained from the Gulf of Kutch, which is recognised as one of the spawning grounds for this species. The coastal region north of Bombay near Daharn is also believed to be another spawning area although there is no record of specimens in roe from this region. However, the occurrence of small specimens of 5.6 and 6.0 cm in length (Nayak, 1959a) in the inshore waters of Bombay, will not rule out the possibility of breeding in these coastal waters. Along the east coast Kuthalingam (1960) has reported spawners in abundance in the inshore waters of Madras and their eggs and larvae in the plankton collections. Thus the breeding grounds for this species appear to be in the gulfs and the inshore areas but the intensity is likely to be more in the former because of the greater abundance of juveniles which form a fishery outside the gulf regions.

Sex ratio:- With the findings of hermaphroditism in many of the polynemid species, the study of sex ratios has become very complicated. The purpose of this aspect of study will not be fully served until the true behaviour of the hermaphrodites in the different species is known. In the study of sex ratios, the presence of the hermaphrodites should also be taken into account as indicated in Table 5.

Apart from these, it is also equally important to give some thought to the information given by some workers in this field on the sexes of P. indicus. Mohamed (1955) and Nayak (1959a) state that the maturing P. indicus caught from Cambay are mostly females. Mohamed observed that some of the catches from Satpati, a fishing village near Bombay, comprised mostly of males. Examining the catches from some fishing villages Deshpande (1962) reports higher percentage of mature females in the night catches during January and February. Further Bhatt et al (1964) have

found that P. indicus landed at the Gulf of Kutch were almost all males. These observations indicate some sort of segregation of sexes. Further studies may throw some light on the shoaling behaviour of the species.

Embryonic development and larval history

Planktonic eggs have an average of 1.3 mm in diameter with large oil globule measuring 0.5 mm. These eggs have been observed to hatch out by about 4½ hours after their collection. Rudiments of scales appeared at the larval length of 24.8 mm. The post-larvae enter the juvenile stage with all the adult characters at a length of 31.8 mm. It has been stated that the larvae start feeding on copepods, copepod eggs and nauplii in the beginning and later exclusively on prawns of Penaeus spp. (Kuthalingam, 1960).

Adult history

Food and feeding habits:- Polynemids are carnivores, feeding on micro- and macro-organisms at different phases of their life. They are generally surface and column feeders, sometimes taking recourse even to bottom feeding. They are predaceous, voracious feeders and at times cannibalistic. The food composition of this group of fishes indicates that when young, they are filter feeders, feeding on planktonic organisms like copepods, nauplii and amphipods. Their food gradually changes over to crustaceans and fishes in the adult phase through an intermediary stage of feeding also on slightly larger planktonic organisms like mysids, megalopa larvae, young prawns and larvae and post-larvae of fishes in addition to the smaller planktonic forms mentioned earlier. The crustacean food of the adult is found to be formed of mostly decapods and stomatopods; polychaetes are also met with in the food of this group of fishes.

Chacko (1949) has recorded that juveniles of P. indicus had exclusively crustaceans as their food in the specimens coming from the Gulf of Mannar. Mohamed (1955) has observed that juvenile P. indicus from the Bombay and Saurashtra waters were predominantly crustacean feeders and that the adults developed piscivorous habit. The food items recorded by him were carid and penaeid prawns, Squilla sp., crabs, sepia, loligo and fishes like Harpodon nehereus, Coilia dussumieri, Otolithus sp., Sciaena sp., Polynemus heptadactylus, elver of eel, Pseudorhombus sp., Saurida tumbil,

Platycephalus sp., Trypauchen vagina and other less important items like fish scales and otoliths and also mud. Karekar and Bal (1958) have grouped P. indicus into juveniles measuring less than 50 cm in length and adults above 50 cm. The crustacean food of juveniles was formed of prawns like Caridea and Acetes sp., Squilla sp. and crabs; the teleosteans contributing to the food at this stage were Bregmaceros macclellandi, Harpodon nehereus, Coilia dussumieri, Sciaenoides brunneus, Otolithus ruber and Muraenesox spp. The food of the adults was formed of prawns, crabs, Squilla sp., isopods, cephalopods and fishes like Coilia dussumieri, Harpodon nehereus, Polynemus heptadactylus, Eleutheronema tetradactylum, Sciaenoides brunneus, Otolithus ruber, Bregmaceros macclellandi, Muraenesox sp., Trypauchen vagina, Stromateus niger, Therapon jarbua, Scatophagus argus, Trichiurus spp. and Arius spp. in varied degrees of importance. Kuthalingam (1960) has remarked that the adults of P. indicus from the Madras waters are selective feeders, feeding on prawns of Penaeus spp. alone. The stomach contents of two specimens from the Arabian Sea, on examination showed to be made of Squilla and prawns, the latter of which were Solenocera indicus, Parapenaeopsis spp., Penaeus spp., and members of the family Alpheidae (Hida, 1967).

Age and growth:- The length frequency studies of P. indicus in the trawl samples from Dwarka region have indicated that the fish grows to 34.5 cm during the first year and measures 54.5 and 74.5 cm by the end of the second and third years respectively, thus showing the growth of 20 cm in each of the two years (Nayak, 1959a). The higher age groups do not occur in good numbers in the trawl catches; they concentrate during the season in the inshore waters of Cambay and Kutch and are caught by the bottom drift gill net locally called 'Waghra Jal'. Since the catch from this gear is very selective, the method of length frequency distribution is not suitable for the samples collected from it. The dominant size in the catch is 91-100 cm. The study of the growth checks on the scales of this species has given very encouraging results. The growth is traced to seven year classes. Based on the observations of the rings on the scales, it is concluded that the dominant size group of 91-100 cm found in the local 'Waghra Jal' may be five years old.

The weight of this fish is found to increase to almost the cube of

its length. Mohamed (1955) expressed this relationship by the formula $W = 0.2406\ L^{4.88325}$. P. indicus measuring 103 cm in furcal length weighs about 15 kg.

Age composition of commercial catches

The trawl fishery of P. indicus from Dwarka and Kutch region is comprised exclusively of juveniles of the first, second and third year classes and also of the intermediate groups of $1\frac{1}{2}$ and $2\frac{1}{2}$ year olds (Nayak, 1959a). Adults in the trawl catch occur in negligible numbers from the Cambay region and they are presumed to be formed mainly of fourth and fifth year classes. The inshore fishery by the bottom drift gill net in the fishing villages of Satpati, Dahanu and others along the Bombay-Cambay coast and also in the fishing villages like Sachana in the Gulf of Kutch is made up of only adults above 80 cm in length. The gear used in these places being highly selective, the catch has only one or two dominant size groups, they being 91-100 and 81-90 cm. These two groups appear to represent the fourth and fifth year classes. Fishes above 100 cm which are over five years old contribute very much less to the catch.

EXPLOITATION

Fishing crafts and gear

In Bombay and Saurashtra waters vessels called 'Hodi' and 'Hoda' of varying displacements between 10 to 20 tons are in operation. These vessels are either sail-driven or power-driven with marine engines of the horse powers usually ranging between 18 and 30. The 'Waghra Jal' is operated on the sturdy plank built boat called 'Galbat' at Satpati; it is manned by 8-11 fishermen. It is of 5-15 tons displacement and has facilities for storing $1\frac{1}{2}$ to 2 tons of ice and 200 to 400 fishes (Deshpande, 1962).

The gross tonnage of the smaller trawlers used from Bombay base varied between 9.95 and 12.88, median trawlers between 34.53 and 48.67 and large trawlers between 52.53 and 123.24. All these trawlers are well equipped with insulated fish holds and deck facilities which help them stay out fishing for 10-15 days at a stretch in the sea.

Polynemids are generally captured in all types of gears used commonly in fishing. They occur as incidental catch in the landings by bag nets, seine nets, gill nets, long lines, hand lines and trawl nets. In Saurashtra the nets employed in fishing P. indicus in the tidal regions are 'Add' and 'Wada' (Bhatt et al, 1964). 'Add' is a barrier net and 'Wada' is a boulder-walled tidal fish trap. This trap is a circular net of 100 to 150 metres in diameter. It is placed with its mouth facing the sea and the water is allowed to pass through it during the flow tide. When the water recedes, this mouth is closed and the water flows out through the stone walls entrapping the fishes.

Along the Bombay-Saurashtra coast a bottom drift gill net called 'Waghra Jal' in Maharashtra and 'Rachh' in Saurashtra is operated during the season for P. indicus. This is a specialized gear used exclusively for P. indicus. This is the sole instance known where a specialized gear is employed for fishing a polynemid species. Here several pieces in varying number between 40 and 125 are tied together to form a large meshed rectangular gill net. The mesh size diagonally slightly varies between 18 and 21 cm in different fishing centres. At the upper margin, to the head rope are attached wooden floats and at the lower margin to the foot rope, sinkers. This net is operated at depths between 15 and 30 metres. Along the Bombay coast, the bottom set long lines are said to yield small quantities of P. indicus (Deshpande, 1962).

P. indicus is obtained by large trawl nets, otter trawl operated by a single trawler and bull trawl by a pair of trawlers. Both these types of trawls are bottom trawls. The wings of the otter trawl net are spread with the help of a pair of otter boards, one on each side, whihh tend to diverge outwards and keep the mouth of the net open. The length of the head rope of the otter trawl nets used from Bombay base vary from 10 to 30 metres, foot rope from 16.2 to 39.0 metres and hunt rope from 8 to 15 metres; mesh at the cod end is 2.5 cm. The bull trawl has two towing lines attached to the mouth of the net and each of the lines is towed by a vessel. The two vessels maintain a certain distance between them in order to spread the wings of the net fully. Shooting and hauling of the net are done alternately by each of the vessels. The length of the head rope of these nets used by the New India Fisheries Co. from Bombay base during 1956-'63 was 67.06 metres, foot rope 68.58 metres and

the hunt rope varied from 180 to 200 metres, mesh at the cod end was 5.08 cm. Off Bombay coast the otter trawls are operated by small vessels less than 100 H.P., median vessels between 101 and 200 H.P. and larve vessels between 201 and 300 H.P. The bull trawls are invariably operated by the larger vessels.

Areas of fishing

P. indicus occurs along the east and west coasts of India in the inshore and the offshore fishing grounds. Along the Bombay-Saurashtra coasts, the inshore fishing grounds extend from Arnala to Daman in the south and from Porbundar to Jakau including the Gulf of Kutch in the north (Deshpande, 1962).

In the Bombay-Saurashtra waters, the bull trawling was first introduced by the Goverrment of India exploratory fishing vessels M.T. 'Ashok' and M.T. 'Pratap' in 1953. Later on it was taken up by the commercial trawlers belonging to the New India Fisheries Co. from 1956 onwards. The unit of fishing ground in the continental shelf is an area of 600 nautical square miles of 30 minute latitude by 20 minute longitude. From Bombay to Kutch these areas are grouped into six regions, viz., Bombay, Cambay, Veraval, Porbundar, Dwarka and Kutch.

The otter trawlers of the Government of India Deep Sea Fishing Station, Bombay, undertaking exploratory fishing, on the contrary follows a different chart. This chart shows major areas, each of 3,600 nautical square miles, at an interval of one degree latitude by one degree longitude. These major areas are further subdivided into smaller units, or the subareas of 100 nautical square miles each at intervals of 10 minute latitude by 10 minute longitude.

Catch

India, one amongst the six countries with polynemid fishery at commercial level was leading in this fishery till 1963 and thereafter ranked only second to Ghana (Kagwade, 1968a) except in 1965 when she ranked next to Ghana and China. During the period between 1956-'65 covering the major part when this fishery was flourishing, the annual average catch of

5.9 thousand metric tons contributed to about 0.8% of the total marine catch of this country (Kagwade, 1968b). A study of Table 6 prepared by extracting from the FAO Fishery Statistics (Anon., 1964 to 1967) shows that polynemid catch of Ghana in 1964 was slightly more than that of India with a marginal difference of barely 0.1 thousand metric tons. The catches which were exceptionally good in the two years of 1965 and 1966 when they were 6.3 and 7.7 thousand metric tons, suddenly recorded a steep fall to 0.8 thousand metric tons in the very next year of 1967. The polynemid landings recorded in the annual reports of the Central Marine Fisheries Research Institute for 18 years from 1951, presented in Figure 3, shows that in the early years when the fishing was by the indigenous sail boats, the annual catches were to the extent of about one thousand metric tons. With the mechanisation of such crafts since 1953, the catches improved. The catches were best in 1955 and 1957, they being 11.6 and 14.5 thousand metric tons respectively. From 1962 onwards, the catches were below 4.8 thousand metric tons which is an average catch for the 18 year period. The extraordinarily good catches in 1955 and 1957 may possibly be due to the effect of mechanisation of the crafts which resulted in better facilities to venture far out into the sea not exploited fully before. From this figure it is also seen that the annual catches were not steady. The catches were better every alternate year in the period when theycatches were extremely good and later on every third or fourth year when they were not so good.

Kagwade (1968a) states that Maharashtra and Gujarat in the north western part contribute 80% to the country's polynemid landings. Of the three commercially known species, P. indicus forms good fishery in the inshore and offshore waters in this region. During the years 1950-'51 to 1956-'57 when the catches were very good, they varied between 12.8% and 26.0% (Nayak, 1959a) and later on during the period of its decline in 1956 to 1963, between 5.36 and 0.89 per cent (Kagwade, 1965). From these facts it is certain that P. indicus is the major species contributing to the country's polynemid landings and any change in the general yield of polynemids will be the result of corresponding change in the yield of P. indicus from the Bombay and Saurashtra waters.

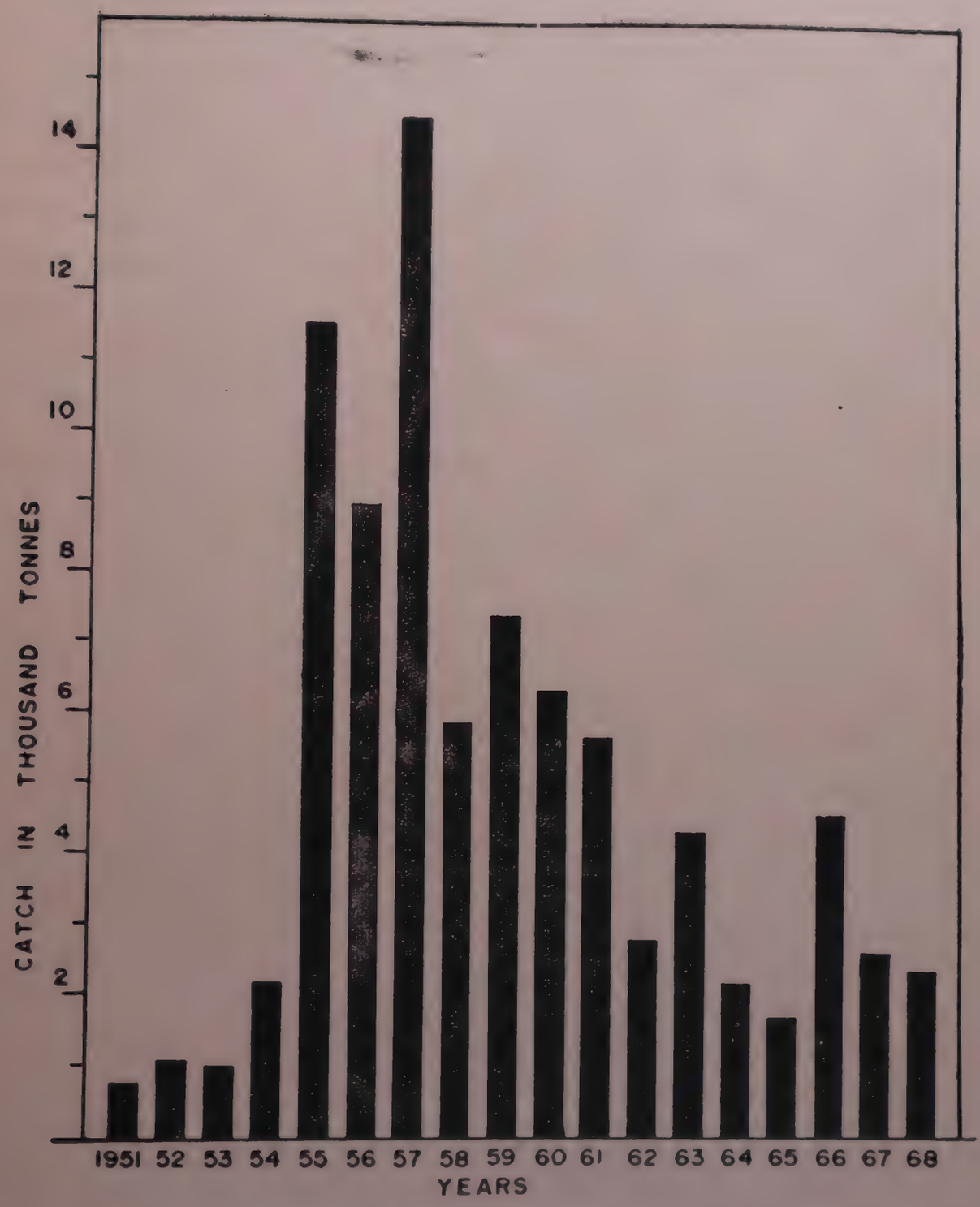

Fig. 3. Annual landings of Polynemids in India for the period 1951—1968.

Regional abundance

Different workers (Mohamed, 1955; Jayaraman et al, 1959; Naik, 1959a and Kagwade, 1965) have repeatedly shown that Dwarka has the richest trawling grounds for P. indicus. The annual catch rate in terms of kilograms per hour has always been recorded the maximum for this region excepting in 1963 when it came next to Kutch (Table 7). The highest catch rates from this region have been maintained almost all through, during the years of flourishing yield as well as of declining yield. The catch rates varied widely between 9.94 kg per hour in the 1963 landings by the New India Fisheries trawlers and 322.5 kg per hour in those of 1954-'55 by M.T. 'Ashok' and M.T. 'Pratap'.

Next to Dwarka ranked Kutch region where the catch rate was 87.96 kg per hour in 1957. Deshpande (1962) has pointed out that in the inshore fishery, the fishing vessels of Satpati going to north and fishing in the Gulf of Kutch where the peak season for this species lasts only for three months, landed on an average about 1,420 P. indicus per vessel during the season while those fishing in the Gulf of Cambay where the season lasts for 6-7 months, landed on an average 1,221 individuals.

From the fishing operations by M.T. 'Ashok' and M.T. 'Pratap' as is presented in Table 7 and also from the observations made by Deshpande (1962), Cambay must necessarily claim to rank next to Kutch. The remaining three regions Bombay, Veraval and Porbundar seem to be more or less equally rich for this species after Cambay. Rao et al (1968) have noted that all the latitude zones between 16°N and 22°N were poor during 1961-'67 but two zones, viz., 16°N and 22°N were slightly better than the others.

The areas 'M' and 'K' with the average catch rates above 100 kg per hour are rich, 'N' moderate and 'L' poor for P. indicus in the Dwarka region and the areas 'P' to 'U' except 'T' are good to moderate and 'V' to 'Z' including 'T' are poor in the Kutch region (Kagwade, 1965). The rich areas mentioned here have yielded the catch at the rate of above 200 kg per hour or even 300 kg per hour in some of the months.

Seasonal abundance

November to May is the season for P. indicus in the Bombay and Saurashtra waters (Table 8) with the peak between November and March

(Nayak, 1959a). Mohamed (1965) has noted its fishery in Satpati during the period February to May but Deshpande (1962) has observed that the fishery begins in December and continues till May with a peak from March to May. He has further referred to a subsidiary fishing for this species at this place for a very short period of 1 to 1½ months soon after south-west monsoon between August and September. In the Gulf of Kutch, the fishery for this species according to Deshpande is during February to May and according to Bhat et al (1964) it is for a shorter period of six weeks between March and May.

Jayaraman et al (1959) have correlated the best catch of P. indicus with low surface temperature, i.e. below 24°C. It is also a known fact that the inshore fishery at the Gulf of Cambay and Gulf of Kutch for this species, is at its best during March-May, a period covering very hot summer months of the year when, based on the observations of Jayaraman and Gogate (1957) and Hida (1967), the temperature is seen to be not less than 27°C to 28°C. From the abundance of juveniles of this species in the fishing grounds of Dwarka which has characteristic low temperature, it appears that in general it prefers cooler waters at this stage. With the approach of hotter months, the juveniles may possibly be getting into deeper waters as they are not found in abundance after March in the Dwarka region. The adults on the contrary must be entering the coastal warmer waters in the hot months for the purpose of breeding. The probable reasons for breeding in warmer waters may be that they provide rich food available therein for the larvae and postlarvae.

Depth-wise distribution

The fishing between the depth range 15 and 516 metres in the Bay of Bengal has revealed polynemids up to 73 metres and the fishing between the depths 15 and 366 metres in the Arabian Sea, has yielded polynemids at the depth range of 18-122 metres (Hida, 1967). This suggests that polynemids are not very deep water fishes.

P. indicus recorded up to the depth range (Table 9) of 61-70 metres (Rao et al, 1968), is generally found to prefer shallower waters up to 45 metres. Its inshore fishery extends up to the depth of 36 metres. During the season it is abundant in very shallow waters between 21-40 metres in the trawling grounds and between 9-26 metres in the inshore fishing grounds.

Lunar periodicity

The catch statistics have revealed that the tidal factors influenced by the lunar phases greatly determine the magnitude of the catches. In the case of P. indicus (Jayaraman et al, 1959), it has been found that it is abundant in the trawler catches during the neap tide period than in the spring tide period. The inshore fishery for this species on the contrary, shows better catches during the spring tide period. Jayaraman et al (1959) have also noticed that day fishing yields better catches than night fishing.

Relation to temperature and salinity

No detailed study so far has been made to correlate the catch abundance of polynemids with the temperature and salinity factors. However, in the case of P. indicus as stated earlier, it has been found that this species prefers cooler waters especially below 24°C (Jayaraman et al, 1959). During the bottom trawling surveys by the Research Vessel 'Anton Bruun' in 1963 in the Bay of Bengal and Arabian Sea P. indicus was recorded at the temperature between 25.56°C and 27.82°C (Table 10). It is noticed that the salinity in the Bay of Bengal has been found to vary during the period of observations between 26.5 and 34.0 °/oo and in the Arabian Sea almost uniform, its value being about 36.0 °/oo. P. indicus in the Bay of Bengal has been collected from a slightly lower salinity value of below 33 °/oo.

III POLYNEMUS HEPTADACTYLUS CUV. & VAL.

IDENTITY

Common names

India	Marathi	...	Shende
	Tamil	...	Ma-kala

Synonyms

Polynemus heptadactylus Cuvier and Valenciennes 1829
Bleeker 1849
Cantor 1850
Day 1878-1888
Weber and de Beaufort 1922
Mendis 1954
Munro 1955

Trichidion heptadactylum Jordan and Starks 1917

Polydactylus heptadactylus Munro 1958

Description

D^1. VIII; D^2. I, 11-13; P. 13-15+7; V. I, 5; A. III, 11-12, L.l. 48-52; L.tr. $\frac{5}{1}$ 10-11.

Length of the head 5 times and height of the body 4 times in total length. Eye diameter $3\frac{3}{4}$ times in head length. Villiform teeth on jaws, vomer and palate. Pectoral rays unbranched, the free filaments reach the base of anal. Air bladder and shoulder blotch absent. Golden in colour (Pl. Fig. 3).

The description of P. heptadactylus from Bombay given below slightly differs from the above (Fig. 4).

D^1. VIII; D^2. I, 12-14; P. 12-14+7; V. I, 5; A. III, 12; L.l. 48-52; L.tr. $\frac{5}{1}$ 10.

Length of the head 4 times and height of the body 4 to $4\frac{1}{2}$ times in total length. A distinct shoulder blotch and an air bladder present.

DISTRIBUTION

East and west coasts of India, Burma, Ceylon, Penang, Malay Peninsula, Moluccas, Indonesia and New Guinea.

Differential distribution

Eggs and larvae:- No information is available.

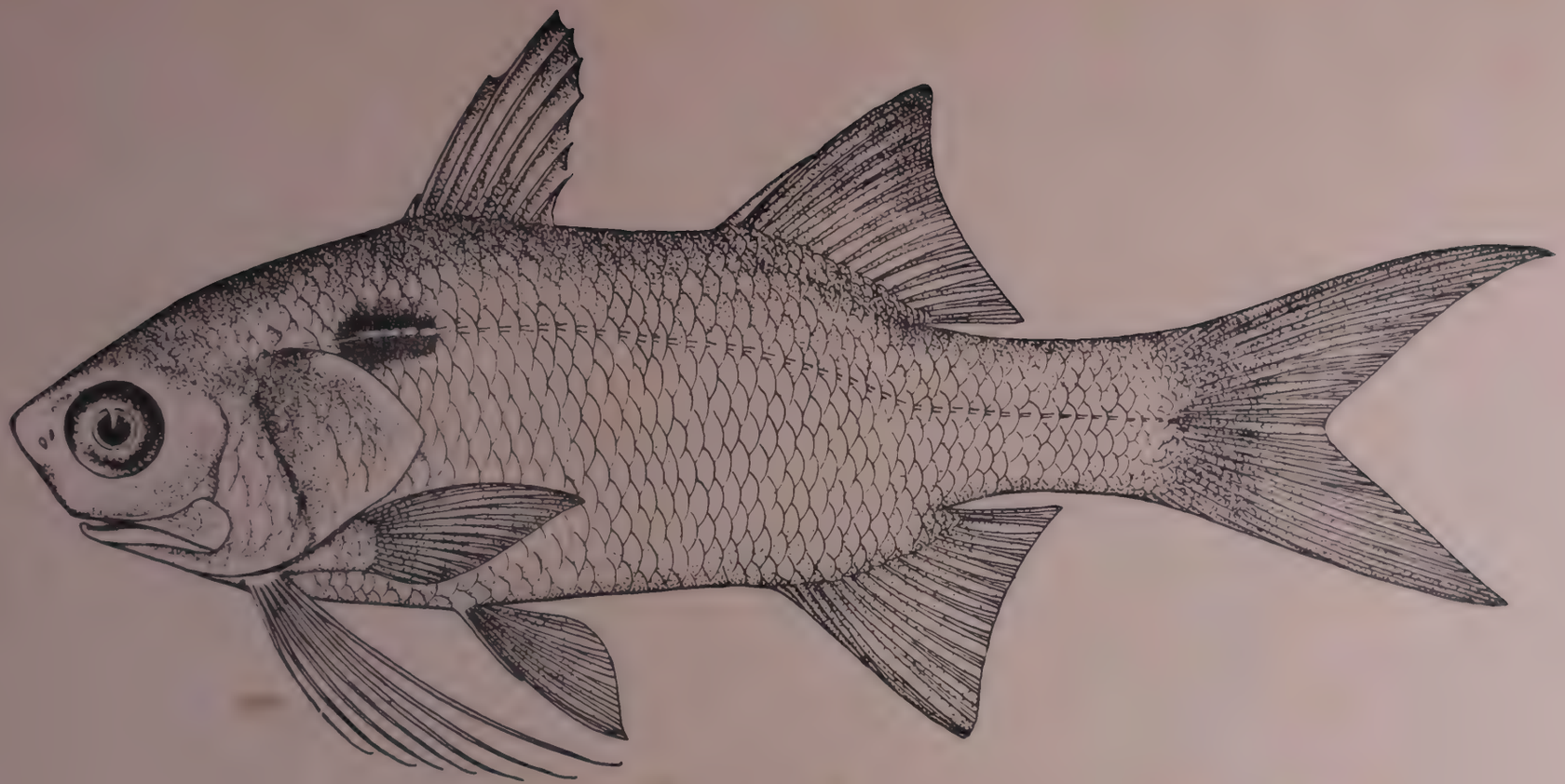

Fig. 4. ***Polynemus heptadactylus*** Cuv. & Val from Bombay region, adult × 6/7.

Juveniles:- Kagwade (1969e) has recorded that the inshore fishery of P. heptadactylus consists mainly of juveniles along the Bombay coast. Specimens as small as 1.5 cm in furcal length are found in the catches.

Adults:- The fishing operation on the trawling grounds between Bombay and Kutch have indicated that adult P. heptadactylus occurs in these grounds all round the year (Kagwade, 1968b); there is marked seasonal variation in the catch abundance. Adults in the inshore waters occur in very small proportion.

Behaviouristic and ecological determinants of the general limits of distribution:- P. heptadactylus is a purely marine species and is found to prefer deeper waters. Like P. indicus, the offshore catch is more during the neap tide period. It falls a prey to many predatory fishes.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality:- P. heptadactylus has hermaphrodite individuals in addition to the usual males and females (Nayak, 1959b). Kagwade (1968c) presented a detailed account on the nature of hermaphroditism in this species. The ovarian part of the ovotestis is found in no way differing from the normal ovary of the unisexuals in the morphological characters such as size and colouration and also in the development of the intra ovarian eggs from immature condition to maturity. There has been no distinction between the mature ova from a hermaphrodite and a unisexual female regarding their sizes and oil globules. The histological changes taking place during the course of development in the two gonadial parts of the ovotestis are explained with the help of microsections. The ovarian and testicular parts separated by a distinct connective tissue layer are found to develop from immature condition to maturity and then to liberate the corresponding sex elements simultaneously and become spent at the same time.

Kagwade (1968c) concludes that hermaphroditism in the species is normal and not teratological since they form a substantial percentage of the catches and also because it is a synchronous hermaphrodite with the two sex elements, viz., ova and sperms, being shed simultaneously. It is

also considered to be functional as sometimes hermaphrodites surpass the unisexual males in number. Though the females attain a larger maximum size than the males and hermaphrodites, the latter two grow to more or less the same size and there is hardly any likelihood of sex reversal taking place in this species since all the three phases appear in almost all the length groups.

Maturation:- Maturity key for P. heptadactylus (Kagwade, 1969c) shows that the diameters of immature yolkless ova measure up to 0.32 mm; opaque, yellow and maturing ova between 0.33 and 0.64 mm and transparent mature ova between 0.65 and 1.04 mm in this species (Table 1). The single oil globule in the mature ovum measures 0.20–0.30 mm in diameter.

Size at first maturity:- The size at first sexual maturity for P. heptadactylus (Table 2) has been found to be 13.3 cm in furcal length in the case of female and 12.8 cm in the case of male (Kagwade, 1969c).

Fecundity:- As is with P. indicus, in P. heptadactylus also amongst the individuals of the same length, the estimated ova have been found to vary in different proportions as shown in Table 3. Kagwade has estimated 65,423 ova in a fish measuring 15.8 cm in furcal length.

Spawning:- Kagwade (1969c) states that spawning in P. heptadactylus is throughout the year but with two peak periods during March-June and August-November (Table 4). Distinction in the spawning intensity of these two peak periods is not recognizable as in the case of P. indicus. Kagwade (1969c) states that P. heptadactylus spawns twice a year and the liberation of the mature ova is in batches.

Spawning grounds:- This species though resembles P. indicus in spawning in the inshore waters, differs much from it in having greater intensity of breeding in the offshore waters (Kagwade, 1969c).

Sex ratio:- The sex ratio in this species is indicated in Table 5. Hermaphroditism is of common occurrence in this species. Hermaphrodites are almost equal to males in numerical abundance. Can these fill the wide gap in the sex ratio between females and males by taking the role of males is not known.

Ponderal index:- The ponderal index has been studied in P. heptadactylus (Kagwade, 1969c). This aspect of study has pointed out that the male and female of this species mature at 12.8 and 13.3 cm respectively. The index is found to fall in both the sexes during the peak spawning periods and then to increase, suggesting recovery of gonads.

Embryonic development and larval history

These aspects are not studied in this species.

Adult history

Food and feeding habits:- Chacko (1949) stated that P. heptadactylus feeds on prawns belonging to the Penaeus spp. and fishes like Sardinella gibbosa and Stolephorus sp. Bapat and Bal (1952) noted prawns having a major role in the food of this species. As the fish grows, fishes are also taken in fairly good proportion. The food items recorded by them are fishes such as Otolithus argenteus and Bregmaceros macclellandi; prawns like Acetes indicus and Acetes sp. and copepods, amphipods, Cypris and polychaetes. Nayak (1965) also observed that crustaceans dominated in the food of this species all through. In the very younger stages planktonic food dominated and it was comprised of calanoid, cyclopoid and harpacticoid forms of copepods, cypris stage of Lepas, amphipods, Lucifer sp. and fish larvae. The other crustacean food was formed of prawns such as Acetes indicus, Parapenaeopsis sculptilis, Hippolysmata ensirostris and Palaemon tenuipes, Squilla sp. and crabs. The fish food was comprised of Bregmaceros macclellandi, Coilia dussumieri, Harpodon nehereus, Sciaena spp., Apocryon sp., Polynemus heptadactylus, Mugil sp., Trichiurus spp., Periopthalmus spp. and Cynoglossus spp. The other food organisms were polychaetes, bivalves, sepia and brittle star.

Age and growth:- The growth patterns useful in age reading are recognized in the form of rings on the scales and otoliths of P. heptadactylus (Kagwade, 1968d). They are readable till the fish reaches fourth year. At the rate of one ring a year, 4 rings are noticed on the scales; but, most of the otoliths of this species, show an extra ring called 'larval ring' formed very early in the life of the fish. 'Larval ring' is absent on the scales; thus, the otoliths show 2-5 rings in fishes between 1-4 years

when the scales show only 1-4 rings. The 'larval ring' appears when the fish is about 2.6 cm in furcal length. The fish is one year old at 8.3 cm in length when it shows 2 rings on the otoliths and 1 on the scales; two year old at 12.8 cm showing 3 rings on the otoliths and 2 on the scales; three year old at 15.8 cm showing 4 rings on the otoliths and 3 on the scales and four year old at 18.8 cm showing 5 rings on the otoliths and 4 on the scales. From these observations the annual growth estimated is 8.3 cm during the first year, 4.5 cm during the second year and 3.0 cm each in the third and fourth years. No difference is noticed in the growth rates of males and females of the same age group. The frequency polygons of the lengths of P. heptadactylus help in tracing the growth till it completes 8 years (Kagwade, 1969b). The growth rates for the first four years are identical to those found earlier by reading the rings on otoliths and scales. After attaining the length of 18.8 cm by the end of the fourth year, the fish measures 21.3, 23.7, 25.5 and 27.3 cm by the end of fifth to eighth years in the same order. The annual increase recorded during the period is 2.4 cm in each of the fifth and sixth years and 1.8 cm in each of the seventh and eighth years. Thus a gradual and more or less uniform fall in the rate of growth in this species is noticed. In both the bag net and trawl net catches, the examination of length frequency distribution has shown two recruitments in a year, one which is the result of premonsoon breeding in the month of May and the other of postmonsoon breeding in the month of November.

During the growth, the weight of male P. heptadactylus (Kagwade, 1969e) is said to increase according to the formula $W = 0.00001089\ L^{3.0832}$ and of the female according to $W = 0.00001147\ L^{3.0745}$ where W = weight and L = length of the fish.

The correlation co-efficients showed that the regression co-efficients in the two sexes are significantly different.

The Walford's growth equation for this species (Kagwade, 1969e) reads as $L_t = 368 \left[1-e^{-0.1545\ (t-(-0.64))}\right]$ where L_t = length of the fish at the age t, 368 = L = maximum or asymptotic length that a fish can theoretically reach, 0.1545 = K = co-efficient of catabolism and -0.64 = t = time or age when the fish length is theoretically supposed to be zero.

Growth characteristics

A factor called the growth characteristic, recognises three distinct periods in the life span of P. heptadactylus (Kagwade, 1969d). This characteristic is expressed by the formula $C = \frac{\log l_2 - \log l_1}{0.4343\ (t_2 - t_1)}\ l_1$ where C = growth characteristic, l_1 = fish length at the beginning of the time interval for which the growth characteristic is calculated, l_2 = fish length at the end of the time interval for which the growth characteristic is calculated, t_1 = time at the beginning of the time interval for which the growth characteristic is calculated, and t_2 = time at the end of the time interval for which the growth characteristic is calculated.

Each of the three periods mentioned above, is associated with some important and specific biological characters. The first period is formed by the juvenile phase of the fish and is greatly influenced by the external environment and the availability of food. It is the period of rapid growth and it covers the first two years of life in the case of P. heptadactylus. The second period is the one of sexual maturity during which the growth is not influenced by the environment but is determined by heredity. This period is formed from third to sixth year in this species. Lastly, the third is the period of old age after the sixth year. The growth during this period is greatly reduced and the spawning activity is doubled. The growth characteristics differ widely in these three different periods but not very much in different years within the same period as is indicated in Table 11.

Age composition of commercial catches

The commercial catches of P. heptadactylus by the trawlers from Bombay and Saurashtra waters are formed mainly of the third and fourth year classes (Kagwade, 1969e), most of the members of which are adults. The first year class is totally absent and the second year class formed by the juveniles is poorly represented. The fifth and the above year classes are meagrely contributing to the catch. The inshore catch of this species by the bag net ('Dol') along the Bombay coast presents a juvenile fishery. The first year class forms the bulk of the catch, second and third year classes are poorly recorded and the fourth year class occasionally in stray numbers. Fishes above this age are almost absent.

EXPLOITATION

Fishing crafts and gear

Along the Bombay and Saurashtra coasts where *P. heptadactylus* is in abundance, the crafts used in the inshore fishery are 'Hodi' and 'Hoda' which are either sail-driven or mechanised boats and in the offshore fishery powered vessels like the trawlers are employed.

This species is caught incidentally along with a variety of other fishes in bag nets and trawl nets. In the Bombay region the bag net used is called 'Dol', which is a big conical, stationary net, fixed to the stakes with the help of sail or mechanised boats in the tidal regions facing the currents at the depths of 15-45 metres. In this position, the fishes get entrapped. When the tide recedes, the net is fixed again in the reverse direction allowing the water to pass through the open mouth of the net in the opposite direction. In this way by the force of current the fishes are driver into the net in both the positions. When the currents are strong, sinkers and floats are used to keep the net in the horizontal position. This net is 43.46 metres in length and 30 metres in breadth at the mouth and a little less than a metre at the tail end. The mesh size varies from 12.7 cm at the mouth to 1.27 cm at the cod end. A miniature type of 'Dol' called 'Bokshi' is used in very shallow waters in this region during the monsoon months. Trawlers use large trawl nets of two types viz., the otter-trawl and the bull-trawls.

Areas of fishing

P. heptadactylus occurs in the inshore waters of Bombay and the trawling grounds of Bombay-Saurashtra waters, but, is important commercially, only when it is from the trawling grounds because of its bigger size. The charting of the fishing grounds in these waters is the same as described earlier (page 15).

Catch

P. heptadactylus which can be accounted in fishery abundance only in the trawler landings contributes to about 3% of the total landings from Bombay and Saurashtra waters by the trawlers of the New India Fisheries Co. (Kagwade, 1968b).

Regional abundance

P. heptadactylus is found to occur in almost equal abundance in Cambay, Dwarka and Kutch with good catch rates ranging between 24 and 27 kg per hour (Kagwade, 1968b). Veraval and Porbundar have been moderately good regions recording the catch of 14 to 17 kg per hour and Bombay very poor with 3 kg per hour. The areas '25', '19', '12', and '11' in the Cambay region, 'H' and 'L' in the Dwarka region and 'Q' in the Kutch region have been considered as rich areas for this species with the catches over 40 kg per hour on record. Some of these areas have yielded this species at the rate of even 100-177 kg per hour (Kagwade, 1968a).

Seasonal abundance

P. heptadactylus is available in the Bombay-Saurashtra waters throughout the year. Kagwade (1968b) points out that there is no marked seasonal variation during a particular part of a year (Table 8). Fluctuations between high and low catches and catch rates occur during any month of a year.

Depth-wise distribution

This species is fished in moderate depths upto 80 metres, the zone of 31-70 metres (Kagwade, 1968b) being that of its abundance (Table 9).

Lunar periodicity

As in the case of P. indicus, the catch of P. heptadactylus is better during the neap tide period than during the spring tide period in the trawler landings (Kagwade, 1968b).

Relation to temperature and salinity

No work has been carried out to study the relation of the catch of P. heptadactylus with temperature and salinity variations.

IV ELEUTHERONEMA TETRADACTYLUM (SHAW)

IDENTITY

Common names

India	Bengali	... Guchhia, Sahal
	Marathi	... Rawas
	Kannada	... Vameenu
	Malayalam	... Bameen
	Tamil	... Pozhakkala or Yevakala
	Telugu	... Maga
	Andamanese	... Tobrodah
Ceylon	Sinhalese	... Kalawa

Synonyms

Polynemus tetradactylus Shaw 1804
Cuvier and Valenciennes 1829
Bleeker 1849
Cantor 1850
Gunther 1860
Kner 1865-1867
Klunzinger 1880
Day 1878-1888
Vinciguerra 1889-1890
Ruther 1897
Seale 1910

Polynemus teria Hamilton and Buchanan 1822

Polynemus salliah Cantor 1838

Polynemus quadrifilis Cantor 1838

Polynemus caecus Macleay 1878

Eleutheronema tetradactylum Bleeker 1862
Weber and de Beaufort 1922
Herre 1953
Mendis 1954
Munro 1955

Eleutheronema tetradactylus Misra 1959

Polydactylus rhadinus Jordan and Everman 1902

Polydactylus tetradactylus Jordan and Richardson (1907) 1908

Polydactylus (Eleutheronema) tetradactylus McCulloch 1913

Fig. 5. ***Eleutheronema tetradactylum*** (Shaw), Juvenile × 1.

Description

D^1. VIII; D^2. I-II, 13-15; P. 16-17+4; V. I, 5; A. II, 15-17; L.l. 75-85; L.tr. $\frac{8-10}{1}$ $\frac{}{13-14}$.

Length of head 5 times and height of body 5-6 times in total length (Fig. 5). Eye diameter 4½ to 5 times in head length. Villiform teeth. Pectorals not branched, free filaments reach nearly to the end of ventral. Air bladder absent. Colour silvery green, becoming yellowish white on the sides and abdomen. A dark mark on the upper portion of the opercle.

DISTRIBUTION

East and west coasts of India, Ceylon, Andamans, Penang, Thailand, Malacca, China, Formosa, Philippines and North and West Australia.

Differential distribution

Eggs and larvae:- Bal and Pradhan (1945 & '46) and Bapat and Bal (1950) have recorded larvae of E. tetradactylum all round the year in the Bombay waters. Sarojini and Malhotra (1952) have obtained larvae and post-larvae of this species in large numbers in the inshore areas of the sea and the tidal creeks from Jaunput (Midnapore Dist.); their collections also have been from riverine centres like Diamond Harbour (River Hooghly), Gosaba (River Gosaba), Sisirgunge (Naipukur River) and Port Canning (River Matla). Ravish (1962) states that numerically larvae and post-larvae of this species are more abundant in Rupanarayan than in the Hooghly or Matla.

Juveniles:- Chacko (1949) states that E. tetradactylum breeds in the inshore waters near Muthupet Swamp (Tamil Nadu) and their young ones move into the swamp for shelter, feeding and growth. Malhotra (1953) has collected a number of young ones of this species from the Hooghly estuary at Diamond Harbour, Jaunput on the Contai coast and Chandipur on the Balasore coast. Chopra (1951) earlier has stated that young ones of this species are found in abundance in the lower reaches of the estuaries of Bengal. Hence, it is believed that the fishery of E. tetradactylum in this part of the country is sustained by the juveniles.

The large sized fish taken from the Chilka Lake where there is a good fishery for it, does not measure beyond 23 cm (Jones and Sujansingani, 1954) and this shows the existence of juvenile fishery for this fish in this lake also. The fishery of this species along Bombay coast is supported by both the juveniles and adults.

Adults:- Adult E. tetradactylum is said to enter Muthupet Swamp (Chacko, 1949) from October to December. Karandikar and Palekar (1950) have found two seasons January-April and July-September for this species in Bombay waters. Literature does not indicate the presence of adults in West Bengal and Orissa (Chilka Lake) where the fishery is contributed mainly by the juveniles.

Behaviouristic and ecological determinants of the general limits of distribution:- E. tetradactylum is known to enter the estuaries in West Bengal for breeding purposes when the salinity of the water starts rising. Ravish (1962) correlates the presence of yolked larvae of this species during February-March to August with the spawning at high salinity.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality:- Sexes are separate. Patnaik (1967) has referred to the occurrence of hermaphroditism in two specimens of E. tetradactylum collected from Chilka Lake, measuring 404 mm and 405 mm in total length. He has found the ovarian portion occupying a narrower area than the testicular portion. The oocytes in the various stages of development measured between 0.7 and 0.21 mm in diameter in the ovarian part and the testicular portion was filled with mature spermatozoa.

Maturation:- Karandikar and Palekar (1950) have recorded immature ovaries with the ova measuring up to 0.4 mm in diameter, maturing with the ova between 0.45 and 0.68 mm and mature with the ova between 0.70 and 1.00 mm (Table 1); the oil globules in the mature ova measure 0.25 to 0.30 mm in diameter.

Size at first maturity:- Karandikar and Palekar (1950) have recorded in

E. tetradactylum, the immature condition till the fish length is 40 cm, maturing condition at 36 cm and spent condition in one specimen measuring 39 cm in length. From these data it may be presumed that this species matures first at a size between 36 and 39 cm (Table 2).

Fecundity:- Study on fecundity is not taken up so far in this species.

Spawning:- In the Bombay waters Karandikar and Palekar (1950) have found two peak spawning periods for E. tetradactylum during January-April and July-September (Table 4). Ravish (1962) has recorded the occurrence of yolked larvae of this species from the Hooghly estuary during the months February-March to August but makes no reference to the peak spawning period. The relative intensities of spawning in the two peak periods mentioned by Karandikar and Palekar are not known. The liberation of the ova is in batches. The spawning appears to be continuous for the species. This is further substantiated by the continuous occurrence of larvae and post-larvae in Bombay waters (Karandikar and Palekar, 1950) and Hooghly estuarine system (Sarojini & Malhotra, 1952; Ravish, 1962).

Spawning grounds:- E. tetradactylum which is an estuarine species is said to enter the Hooghly river and move further up for breeding. Ravish (1962) however, doubts the justification of the supposed breeding places in Hooghly, in the stretch of the river below Budgebudge and at Canning in the Matla, because of the presence of yolked larvae in very small number in these areas. He finds the larvae and post-larvae in greater numerical abundance in the Rupnarayan area than in the Hooghly or the Matla. Jones and Sujansingani (1954) point out that this species does not breed in the Chilka Lake near the mouths of the rivers as suggested by Chaudhuri (1917); they reason it by the total absence of adult females in the III-IV stages of maturity, the juvenile and young stages found in the lake thus being the immigrants from the sea. In the creeks around Bombay, E. tetradactylum in different stages of maturity are obtained. The availability of mature specimens and their larvae and post-larvae from inside the creeks suggests that the breeding of this species is in the inshore waters in the Bombay region.

Sex ratio:- No information is available on this subject.

Embryonic development and larval history

Sarojini and Malhotra (1952) have traced the development of larvae of E. tetradactylum from 6.0 mm till they enter the juvenile phase. The pectoral fold is said to get differentiated into a main lobe and a sub-lobe, the former developing into pectoral fin and the latter into four free pectoral filaments. The air bladder is well developed in the larval stage but becomes vestigeal in the juvenile and adult stages. The scales start appearing when the fish is about 15 mm long and they look cycloid with one circulus. At the length of 17 mm, ctene start appearing and when the post-larvae are about 19 mm, the scales become distinctly ctenoid and when at 30 mm, attain the appearance of scales found in the adults.

Adult history

Food and feeding habits:- Malhotra (1953) has not noticed much difference in the food composition among individual fish from different environments (marine and estuarine). He has divided the fish into three size groups, viz., size group I from 0.7 to 3.0 cm, size group II from 3.1 to 6.0 cm and size group III from 6.1 cm and above.

The food composition of the fish belonging to the size group I has been found to comprise mainly of copepods, the species of which are Acartiella major, Acartiella spp., Pseudodiaptomus spp. and Centropages spp., Oithona sp., Cyclops spp. and Cyclopina spp. Mysids found are Macropsis orientalis, Macropsis sp. and Potamomysis sp.; these along with other crustaceans like Lucifer spp., shrimps, prawn larvae and branchiopods have been of secondary importance. Fish larvae have been found only in one specimen. In the size group II, the crustaceans noticed have been prawns, Penaeus indicus, Penaeus sp. and Metapenaeus sp., shrimps mostly Acetes sp.,megalopa larvae of Varuna litterata and mysids of the species Macropsis orientalis, Macropsis sp. and Potamomysis sp.; the copepods found have been Acartiella major, Acartiella spp., and Acartia sp. and sometimes amphipods. In specimens from marine environment, fish larvae have been found to occur in good proportions during July and August.

The crustacean food in the fish belonging to the size group III has been seen to be made up chiefly of prawns like Penaeus indicus,

P. carinatus, Penaeus sp., Metapenaeus monoceros and Metapenaeus sp., shrimps like Acetes sp., a megalopa larvae of Varuna litterata; others of less importance are Lucifer spp., young crabs, mysids represented by Macropsis orientalis, Macropsis sp., Potamomysis assimilis and Potamomysis sp., amphipods like Paracalliopa sp., ostracods and isopods. The fish food, occurring more often during the months of November to May in the estuarine and Chilka specimens and during July to October in the marine specimens, has been noticed to consist of mullets of the species Mugil speigleri, M. parsia and M. tade, engraulids of Thrissocles spp. and Coilia sp. and percoids of Sciaena sp. mostly, Sillago panijus, Sillago sp., Barbus sp. less frequently and Eleutheronema tetradactylum, Icthyocampus sp. and Hilsa sp., each of the three only once and singly. Polychaetes have been in maximum during June in the estuarine specimens.

Bal and Pradhan (1945) mention that Sagitta forms the main food of E. tetradactylum from Bombay waters but Sarojini and Malhotra (1952) and Malhotra (1953) have found it only occasionally in the mouth of the fish and attributed this to its accidental inclusion since it is not encountered among the stomach contents. Bapat and Bal (1952) have stated that in fishes up to 5 cm, the main food consists of copepods and prawn larvae and in slightly larger fish upto 10 cm, the food is comprised of polychaetes mostly during rainy season and Squilla larvae. Malhotra (1953) however, has noticed young prawns in the food of specimens from the estuarine environment only and not from the sea. He also has observed that polychaetes are absent even during the rainy season. He has pointed out that the observations by Bapat and Bal that only polychaetes and Squilla larvae are found in the fish of the size 5-10 cm from Bombay waters and by Chacko (1949) that only Penaeus sp. and Acetes sp. are found in the stomachs of this species in sizes between 12 and 18 cm from the Gulf of Mannar, reflect on the nature of environments on the different coasts. Venkataraman (1960) has found that in E. tetradactylum from the Calicut coast, the food consisted mainly of prawns and then teleosts in the size between 10 and 28.5 cm; occasionally intensive feeding on polychaetes, the principal species being Prionospio pinnata, was also met with.

Age and growth:- This aspect is not studied in this species.

EXPLOITATION

Fishing crafts and gear

Along the Bombay coast fishing boats called 'Hodi' are used in fishing E. tetradactylum and in Bengal 'Dinghies'.

It is fished mostly by gill nets and sometimes caught by the trawl nets also in the Bombay waters. The gill nets are used in Calicut (Venkataraman, 1960) and also in Chilka Lake where they are known as 'Khainga-jal' (Jones and Sujansingani, 1954). Boat seines (Venkataraman, 1960) at Calicut and drag nets called 'Sahala jal' in Chilka Lake are also employed. In Hooghly and Matla estuaries, small bag nets called 'Bin-jal' are operated in places where strong currents of both ebb and flow tides occur (David, 1954; Pillay and Ghosh, 1962). The number of meshes around the mouth of this net varies from 300-700. Mesh size at the periphery of the mouth is about 4 cm and at the cod end when stretched, it is 1.4 cm. In places where the catches are very good, fishermen, instead of waiting for the change in the direction of the current, haul the cod end and empty the catch every one or two hours.

Areas of fishing

During the season, there is fishing for this species in the inshore waters of Bombay and also in the Hooghly estuarine system.

Catch

Though there is no estimation of the catch of E. tetradactylum separately from other species, its magnitude can be judged from the report on the marketing of fish in the Indian Union (1951). It is found that 3.23% of the total catch from the Bombay coast and 2% of the total catch from the Kathiawar coast comprised of this species and the two together contributed from the Bombay and Saurashtra coasts. In Orissa and West Bengal it formed 13.2 and 4.3% respectively of their total landings. It is encountered occasionally in trawl catches in small numbers, but does not support a trawl fishery.

Seasonal abundance

Pillay and Ghosh (1962) have noted that in the bag net fishery of

the Hooghly-Matlah estuarine system, polynemids occur almost all round the year. E. tetradactylum is said to have a fishery of appreciable size in August and September (Table 8). Karandikar and Palekar (1950) earlier have found that this species has two fishery seasons from January to April and July to September in the Bombay waters. The latter of these two seasons corresponds to the one at Hooghly-Matlah estuarine system mentioned by Pillay and Ghosh.

Relation to temperature and salinity

The relationship of the catch of E. tetradactylum with either temperature or salinity is not known. However, it may be said that since its fishery appears prior to warm summer months and during the rainy season, it prefers moderate temperature and not either of the extremes.

V POLYNEMUS PARADISEUS LINNAEUS

IDENTITY

Common names

India	Bengali	...	Tapsee machh
	Marathi	...	[illegible]
Burma	Burmese	...	Ngapoonana

Synonyms

Polynemus paradiseus Linnaeus
Day 1878-1888
Misra 1959

Description

D^1. VII; D^2. I, 15-16; P. 15+7; V. I, 5; A. II, 12; L.l. 70; L.tr. $\frac{5}{14}$.

Length of the head and height of the body about 6 to 6½ times the total length (Fig. 6). Eyes minute in young and about 8 times in the length of head. Teeth villiform in jaws, vomer and palate. Pectoral rays

undivided with 7 free filaments at its base, the upper 3 longest, strongest and about twice length of the fish. Caudal deeply forked, upper lobe longer. Air bladder absent. Lateral line forms a curve and gets lost in the middle of the base of the caudal fin. Golden colour with a tinge of gray colour at the back, fins gray.

DISTRIBUTION

India, Burma and Malay Archipelago.

Differential distribution

Eggs and larvae:- Eggs with advanced stages of embryos have been collected by Jones and Menon (1953) from the Hooghly river at Barrackpore on several occasions. Ravish (1962) has observed the occurrence of the yolked larvae of this species in abundance from the Rupnarayan area and in scarcity from the Hooghly area.

Juveniles:- Juveniles of P. paradiseus are obtained at Barrackpore on the Hooghly river (Jones and Menon, 1953; David, 1954) and also along the Burmese coast (Hida, 1967).

Adults:- Adult P. paradiseus are collected from the Hooghly river (by Jones and Menon, 1953; David, 1954; Gupta, 1968). Based on the observations of David and Gupta, it appears to occur during April to July.

Behaviouristic and ecological determinants of the general limits of distribution:- Ravish (1962) correlates the larval abundance of P. paradiseus with low salinity in the Hooghly estuary.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality:- Sexes are separate. Hermaphroditism is not met with in this species.

Maturation:- Gupta (1968) has studied the ova diameter measurements in P. paradiseus. He has drawn the ova diameter frequency curves. From the graph the largest diameter of the intraovarian egg appears to be almost 1.0 mm. By the probability analysis he has arrived at the modal sizes of

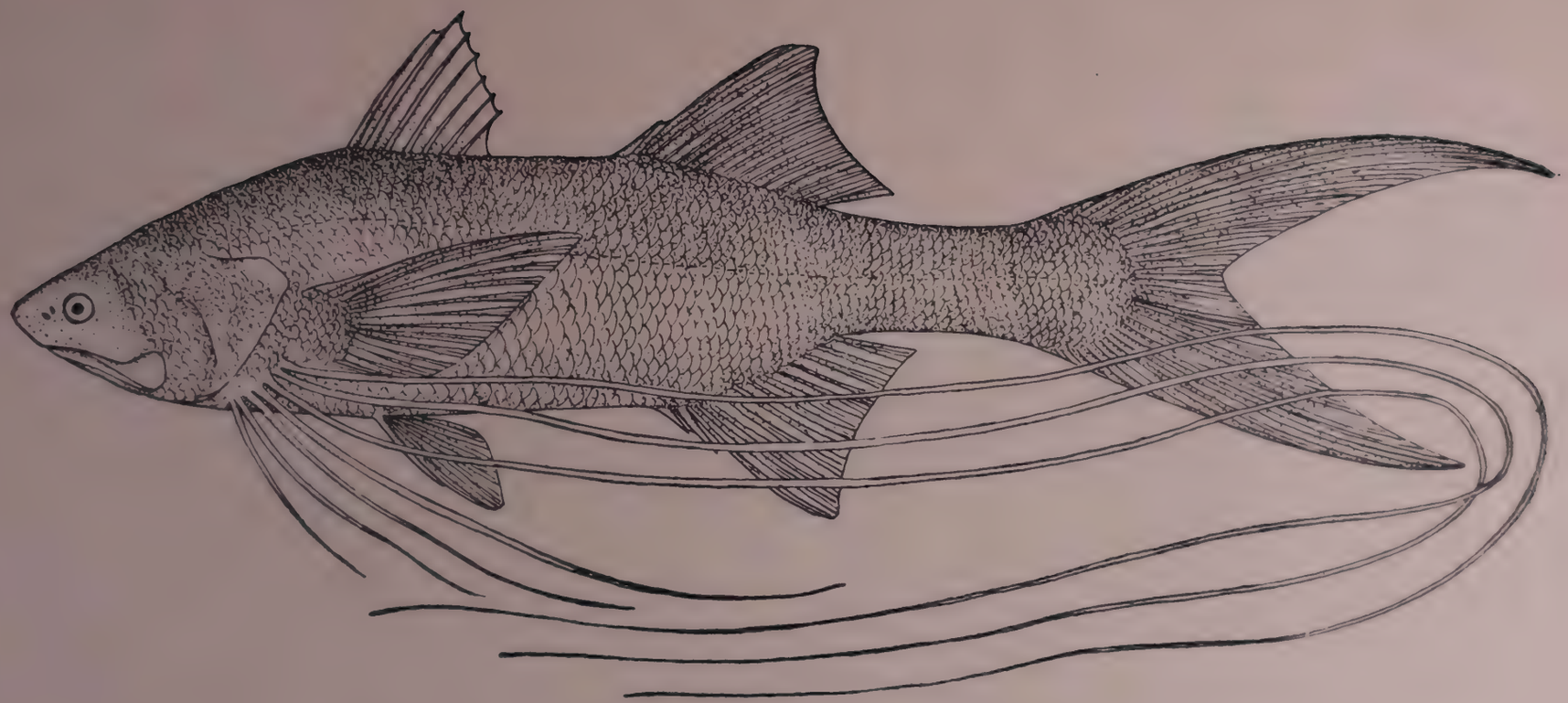

Fig. 6. ***Polynemus paradiseus*** Linnaeus, Juvenile × 1.

the ova at different stages of maturity as shown below:

Stage		Modal size in mm
II	..	0.30
III	..	0.54
IV	..	0.76
V	..	0.83
VI	..	0.85

He considers stages V and VI as fully mature in which the ova measure above 0.83 mm. But Jones and Menon (1953) have collected fertilized eggs of this species measuring 0.7 mm in diameter and possessing an oil globule of 0.4 mm in diameter. By studying the results of these works together, it is possible that the immature ova of P. paradiseus measure up to 0.30 mm in diameter, the maturing ova approximately 0.69 mm and the mature ones above this till about 1.0 mm.

Size at first maturity:- Jones and Menon (1953) in their collection from the Hooghly river at Barrackpore have noticed mature P. paradiseus ranging between the size 12.5 and 17.5 cm in standard length and juveniles from the larval stages to the size of 7.0 cm; there has been a distinct gap between the adult and juvenile stages in the collection. The same is true with the findings of David (1954) who mentions that in the Hooghly river, young ones of this species up to 8.0 cm and adults above 15.0 cm only occur and that individuals between these two lengths do not occur at any time of the year. Hida (1967) has recorded P. paradiseus of the sizes between 8.0 and 14.3 cm in standard length in the Bay of Bengal along the Burmese coast. Only two females of the sizes 12.2 and 14.3 cm have been found to be mature females. Gupta's (1968) collection includes fishes of the sizes between 15.4 and 20.7 cm in total length. From the maturity curve drawn by plotting the percentages of mature male and female specimens against their corresponding total lengths which are all above 15.4 cm, he infers that the males mature at 13.5 cm and the females at 16.0 cm (Table 2). He also opines from this graph that at 14.0 cm, all the females and at 11.0 cm, all the males are immature. But from the observations of Jones and Menon (1953) and Hida (1967) who recorded mature individuals between the sizes 12.2 and 14.3 cm, the length of 16.0 cm as the size at first sexual maturity for females appears to be rather a bigger length and the difference of nearly 4 cm between the size when the

fish is seen to be mature and the inferred size at first maturity is possibly due to the absence of fish of the size between 12.0 and 15.0 cm in Gupta's collection. It would be useful as a supporting evidence to know the smallest size of the spent individual to fix the size at first maturity.

Fecundity:- Gupta (1968) has carried out a detailed study on the fecundity of P. paradiscus. In this species where there is a single and short spawning, he has been able to establish an exponential relationship between the fish length and fecundity and linear relationships between the weight of the fish and fecundity and weight of the ovary and fecundity. It is very interesting to note that the fish from Rupnarayan estuary was more fecund than that from Hooghly estuary and further that the fish from Hooghly estuary was more fecund during 1966 than during 1965. In order to determine whether these differences are genetically or environmentally effected, the author has undertaken the morphometric studies of the specimens coming from the two estuaries. Lastly he has noticed the right gonad to be invariably more fecund than the left one. Jones and Menon (1953) have estimated 42,000 ova in P. paradiseus measuring 17.0 cm. From the graph of Gupta (1968) it is assessed that the fish just a little above 22.0 cm has a fecundity of over 65,000 ova.

Spawning:- Jones and Menon (1953) suggest that P. paradiseus has an extended breeding time, at least from January to June. From the catch comprising of adults with gravid gonads from the latter part of April onwards and also from the presence of a large number of their young ones in May-June in the Hooghly river, David (1954) believes that this species spawns during March-June which probably may be the peak period (Table 4). Ravish (1962) has noticed the presence of yolked larvae of this species during April to November, indicating a prolonged spawning period and also the peak period of abundance for these larvae during July to August. These larvae appear to be the result of peak spawning during March-June mentioned earlier by David (1954). Gupta (1968) states that from April to July, this species ascends the estuary for breeding and May-June is the peak spawning period (Table 4).

Spawning grounds:- Depending on factors such as salinity and other hydrological characters, the breeding zone of P. paradiseus is said to shift

up and down the tidal portion of the Hooghly river (Jones and Menon, 1953). The early larval stages collected also indicate the possible breeding in the lower reaches of the estuary and adjacent coastal waters. From the presence of males with milt and females with oozing ova in the Hooghly river, David (1954) suggests that this fish probably ascends higher up the river for breeding purposes. Ravish (1962) points out that in the gradient zone with low salinity of the Hooghly estuarine system, the yolked larvae of this species are more abundant in the Rupnarayan area and more scarce in the Hooghly area and hence, he infers that the main spawning ground of this species is in Rupnarayan area. According to Gupta (1968), it breeds around Barrackpore in the Hooghly estuary and near about Ananthpore-Kolaghat region of the Rupnarayan estuary.

Sex ratio:- Jones and Menon (1953) have pointed out that in the collection from 'Bhin-jal', a fixed bag net, the male and female P. paradiseus appeared in 1:1 proportion whereas in the collection by hook and line, the females formed only 2-5% and males the remainder.

Embryonic development and larval history

Studies by Jones and Menon (1953) have shown that the pelagic, transparent, fertilized eggs of P. paradiseus measure 0.7 mm in diameter and possess an oil globule of the size 0.4 mm in diameter. The embryos in the collection have been in advanced stage of development and hence the incubation period is not known; the hatching occurred 2 to 4 hours after the collection. The air bladder develops in the larval stage and gets atrophied in the juvenile and adult stages. The yolk gets absorbed after 4.3 mm stage and the rudiments of scales appear when the larvae measure 13 to 14 mm in length. They feed on copepods and most of the larval characters are lost when it is about 15 mm long. With the addition of chromatophores, complete formation of scales and elongation of pectoral filaments to the full length, the larvae enter into the juvenile stage.

Adult history

Food and feeding habits:- Slight differences were noticed by Hida (1967) in the food composition of P. paradiseus from the two trawling stations

'40' and '44' along the Burmese coast. Penaeid and Alpheid prawns, gammarid amphipods and others like Paracalanus sp., Neomysis hodgarti, Squilla oratoria inornata and remains of the fish skeleton were the food contents of the specimens from the station '40'. Fishes and mysids were totally absent and amphipods were less frequent in the food of specimens from the station '44'; the prawns found in their food were Parapenaeopsis stylifera, P. uncta, Metapenaeus brevicornis and Penaeus indicus, the tiny crabs were Charybdis callianassa and the only copepod was Calanopia elliptica.

Age and growth:- No information is available on the age and growth of this species.

EXPLOITATION

Fishing crafts and gear

In the Hooghly river P. paradiseus is fished by small boats called 'Dinghies'. In the Bay of Bengal it is fished by trawlers (Hida, 1967). In the Hooghly estuarine system it is captured by small bag nets called 'Bin-jal' and also by long lines with 200 to 500 hooks of No.16 and 17 with prawns as bait (Jones and Menon, 1953). Hida (1967) has recorded it in trawl net.

Areas of fishing

This species is fished from the Hooghly estuarine system.

Catch

Catch record is not maintained separately for this species.

Regional abundance

In the absence of catch data, the regional abundance is not workable for this species.

Seasonal abundance

Pillay and Ghosh (1962) have noticed that P. paradiseus is

available throughout the year in the Hooghly-Matlah estuarine system with the peak during May to October (Table 8).

Depth-wise distribution

During the trawling survey of the Bay of Bengal, Hida (1967) has recorded P. paradiseus from the shallow waters between 15 and 27 metres (Table 9).

Relation with temperature and salinity

From the data collected by Hida (1967) it is seen that P. paradiseus is recorded from warmer waters above 26.09°C and from lower salinity below 33 °/oo (Table 10).

VI POLYNEMUS SEXTARIUS BLOCH & SCHNEIDER

IDENTITY

Common names

India Tamil ... Kutli kala

Synonyms

Polynemus sextarius Bloch and Schneider 1801
Bleeker 1849
Gunther 1860
Day 1878-1888
Gilchrist and Thompson 1908
Weber and de Beaufort 1922
Mendis 1954
Munro 1955

Trichidion sextarius Bleeker 1865

Trichidion sextarium Jordan and Starks 1917

Polydactylus sextarius Smith 1953
Misra 1959

Description

D^1. VIII; D^2. I, 12-13; P. I, 12-13+6; V. I, 5; A. II-III, 12-13; L.l. 48-50; L.tr. $\frac{5}{1}$ 9.

Length of the head 4 times and height of the body 4 to $4\frac{1}{2}$ times in total length. Eye diameter 3 to $3\frac{3}{4}$ in head length. Villiform teeth on jaws and palatines, vomer without teeth. Pectoral rays branched, free filaments reach the middle of ventral fin or sometimes its end. Air bladder simple and small. Golden in colour, fins generally with black spots. A large shoulder blotch on the lateral line (Pl.Fig.2).

DISTRIBUTION

East coast of Africa, India, Ceylon, Penang, Thailand, China and Australia.

There is no further knowledge about the distribution at different stages of life in this species.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality:- Hida (1967) has noticed a high percentage of hermaphrodites occurring amongst P. sextarius and stated, "P. sextarius undergoes a protandrous change through a juvenile-hermaphrodite-female progression. This species first reached sexual maturity as a functional male hermaphrodite; there is no evidence that females developed directly from juveniles".

There is no information on the maturation, size at maturity, fecundity, spawning, spawning grounds, embryonic development and larval history of this species. However the only knowledge on the sex ratio is presented in Table 5.

Adult history

Food and feeding habits:- Mookerjee et al (1956) have noticed that the crustaceans formed the major food item of P. sextarius from Port Canning

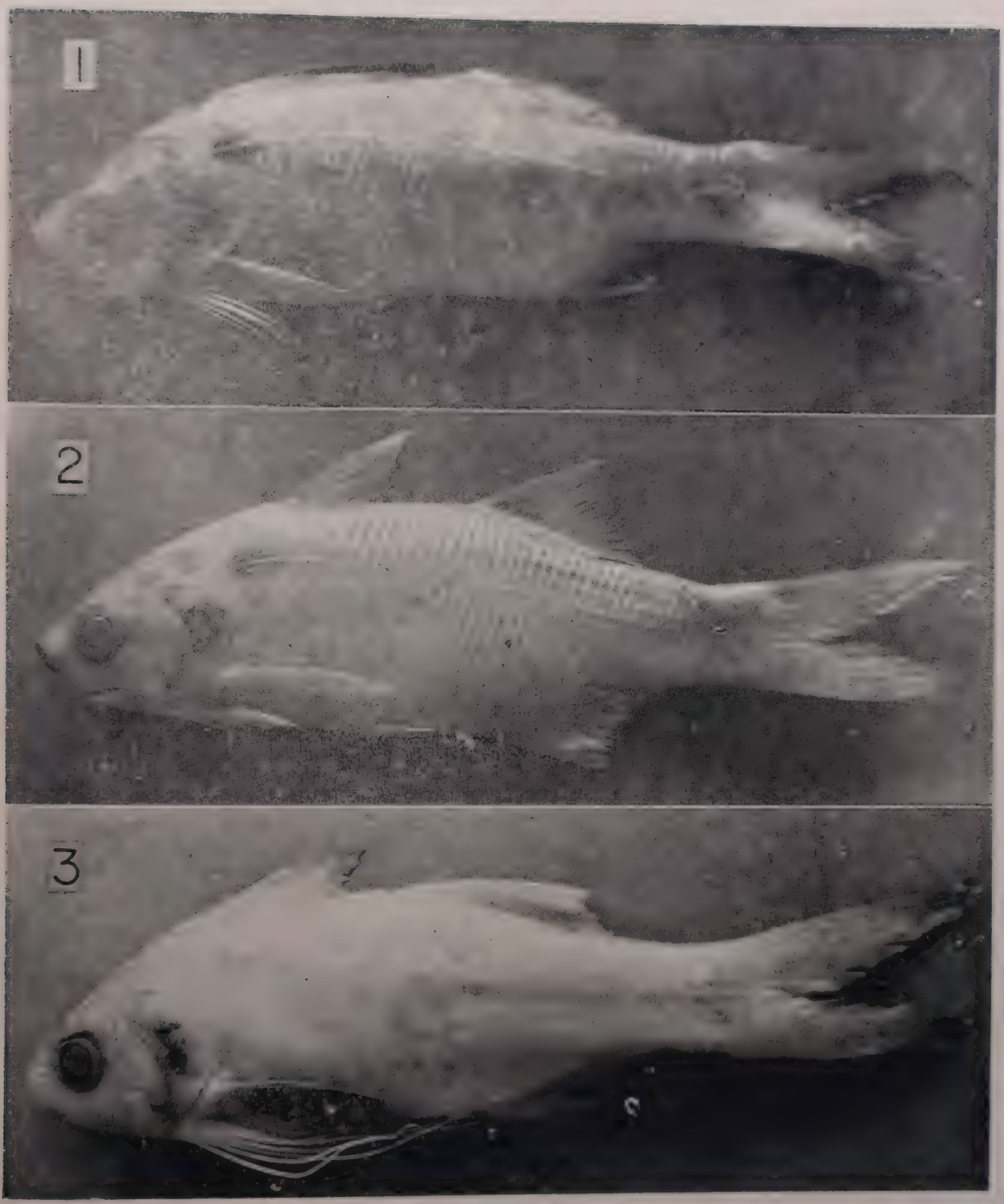

Plate fig. 1. ***Polynemus microstoma*** Bleeker × 9/10
,; 2. ***Polynemus sextarius*** Bl. & Schn. × 9/11
,, 3. ***Polynemus heptadactylus*** (Cuv. & Val) × 1

the other food items being fish, protozoa and even algae. Hida (1967) noticed some differences in the food composition of this species collected from two slightly different environments, one from south of Rangoon and the other from south of Chittagong along the Burmese border. Shrimps and amphipods were found in all the specimens examined from south of Rangoon. The shrimps included Solenocera sp., Penaeus sp. and members of the family Processidae and the amphipods Gammarus sp., Jassa sp., Cheiriphotis sp. and Harpinia sp. The crabs found Charybdis callianassa and Neptunus sp. and the mysids were Erythrops minuta, Neomysis indica and Hypererythrops spinifera while the rest were formed by other forms like stomatopod - Squilla oratoria, isopod - Cirolana sp., copepod - Eucalanus sp., lobster - Scyllaridae, anomuran - Callianassidae and flatfish - Bothidae. The specimens from south of Chittagong showed shrimps as the principal food item in all and they represented the families Pandalidae, Alpheidae, Penaeidae and Sergestidae. Gammarid amphipods, portunid megalops and a mysis, Acanthomysis indica were other items of less importance. Fish and polychaetes were totally absent and mysids and crabs occurred less frequently and in these respects the food composition of this set of specimens differed from that collected from south of Rangoon.

There is no knowledge on the age and growth and age composition of commercial catches of this species.

EXPLOITATION

Fishing crafts and gear

It is captured incidentally along with other fishes by all the commonly employed gears in the inshore waters on the east coast. During the trawling survey of Bay of Bengal, this species was caught in trawl net.

Areas of fishing

It is fished in Bay of Bengal.

The catch and regional and seasonal abundance of P. sextarius are not known.

Depth-wise distribution

P. sextarius is found to inhabit moderate depths between 19 and 73 metres (Hida, 1967) as shown in Table 9.

Relation to temperature and salinity

This species is recorded from grounds of moderate temperature between 23.98°C and 26.16°C where the salinity is found to be 32.99-34.00 °/oo (Table 10).

VII POLYNEMUS PLEBEIUS BROUSSONET

IDENTITY

Common names

India	Tamil	...	Pole kala Barmeen
Ceylon	Sinhalese	...	Bandi kalava

Synonyms

Polynemus plebeius Broussonet 1782
Day 1878-1888
Herre 1953
Munro 1955

Polynemus lineatus Lacepede 1803
Gunther 1860
Kner 1865-1867

Polynemus plebejus Cuvier and Valenciennes
Bleeker 1849
Gunther 1873-1875
Steindachner 1896
Weber 1913
Weber and de Beaufort 1922
Mendis 1954

Polynemus taeniatus Gunther 1860
Gilchrist and Thompson 1908

Trichidion plebejus Bleeker 1862

Polydactylus plebeius Jordan and Seale (1905) 1906
Seale 1906
Seale and Bean 1908
Fowler 1938, 1949
Smith 1953

Polydactylus agonasi Jordan and McGregor 1906

Polynemus agonasi Franz 1910 (1911)

Polynemus hydiae Curtiss 1938

Description

D^1. VIII; D^2. I-13; P. 17-18+5; V. I,5; A. II-III, 11; L.l. 60-65; L.tr $\frac{6-7}{12}$. L.tr. $\frac{1}{12}$.

Length of head about $4\frac{1}{2}$ times and height of body about 5 times of the total length. Eye diameter $3\frac{3}{4}$ to 4 1/3 in the head length. Interorbital space slightly convex. Mouth large, reaching far behind eye. Maxillaries scaly. Teeth villiform. Pectoral rays unbranched, five free filaments, the uppermost reaching beyond the ventral. Caudal fin pointed. Air bladder elongated, narrow and simple. Lateral line continued along the lower lobe of the caudal fin. Colour golden, slightly grayish at the back and dark lines along each row of scales.

DISTRIBUTION

This is the most widely distributed species found along the coasts of Natal and Madagascar, Bourbon, Mauritius, India, Ceylon, Penang, Thailand, Japan, Formosa, Philippines, Australia and the Islands of New Hebrides, Solomon, Samoa, Fiji, Tahiti and Marquesas.

Knowledge on the distribution at different stages of life of P. plebeius is lacking.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality:- Sexes are separate. Hida (1967) has come across only one hermaphrodite individual amongst the 10 specimens of P. plebeius

collected (Table 5).

There is hardly any knowledge on the maturation, size at maturity, fecundity, spawning, spawning grounds, sex ratio and embryonic development and larval history of this species. However, Day (1878) has recorded females in roe as early as March.

Adult history

Food and feeding habits:- The food composition of P. plebeius in sizes between 9.9 and 18.5 cm from the Calicut coast has been noticed to be mainly of a common crab occurring in the muddy bottom in the inshore region, namely, Emerita asiatica (Venkataraman, 1960). Hida (1967) recorded the presence of fishes like Bregmaceros sp. and Polynemus sextarius var. mullani, small sized crabs, possibly of the genus Charybdis, penaeid prawns, sergestids, octopods and gastropods in the stomach contents of this polynemid fish from the upper part of the Arabian Sea.

Hardly any information is available on the age and growth and age composition of commercial catches.

EXPLOITATION

Fishing crafts and gear

This species is caught incidentally in seine nets and gill nets. It appears in trawl nets also.

Areas of fishing

P. plebeius is in fishery abundance along the coast of West Pakistan.

Nothing is known about the catch and regional or seasonal abundance.

Depth-wise distribution

This species is found to inhabit from shallow to relatively deep waters in 23-122 metres (Hida, 1967) as indicated in Table 9.

Relation to temperature and salinity

This species is recorded from moderate temperature of (Table 10) 23.54-25.40°C and the salinity of 36.33-36.71 °/oo (Hida, 1967).

VIII POLYNEMUS XANTHONEMUS CUV. & VAL.

IDENTITY

Common name:

Ceylon Sinhalese ... Kalawa

Synonyms

Polynemus xanthonemus Cuvier and Valenciennes 1831
Day 1878-1888
Southwell 1913
Munro 1955

Polydactylus xanthonema Deraniyagala 1933

Description

D^1. VIII; D^2. I, 11; P. 15+6; A. III, 11-12.

Free pectoral filaments extend beyond the end of ventral. Caudal deeply cleft. Air bladder absent. Greenish back, silvery abdomen and sides, yellow fins with black border.

DISTRIBUTION

Day (1878) describes its distribution from the seas of India to China, however, he did not get any specimen from Indian waters. This species is recorded from Ceylon and recently Hida (1967) collected a number of specimens of this species from the east coast of India during the bottom trawling surveys in the Bay of Bengal.

There is no knowledge on the different aspects of distribution at the various stages of life.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality:- Sexes are separate. Though not many, Hida (1967) has recorded some hermaphrodites in this species. It is stated that protandrous change in this is unlikely because of the narrow size range of 9.0 to 11.5 cm within which the males, females and hermaphrodites appeared simultaneously.

Information on the maturation, size at first maturity, fecundity, spawning, spawning grounds, and embryonic development and larval history of this species are not available in the literature. The sex ratio of this species is presented in Table 5.

Adult history

Food and feeding habits:- P. xanthonemus collected by Hida (1967) from the Burmese coast, showed in the stomachs the mysids like Acanthomysis indica, Gastrosaccus mutticus, Pleurerythrops insolita and Mysidopsis kempi, penaeid and sergestid prawns, gammarid amphipods, barnacle cyprides and copepods such as Temora turbinata, Calanopia sp., Oncaea sp. and Labidocera sp.

Nothing is known about the age and growth and age composition of the commercial catches of this species.

EXPLOITATION

Fishing crafts and gear

It comes in the trawling nets as incidental catch.

Areas of fishing

Bay of Bengal along the Burmese coast when trawled recorded this species.

Information on the catch and regional and seasonal abundance of this species are yet to be collected.

Depth-wise distribution

P. xanthonemus is a shallow water species (Table 9) found in 19-30 metre depth range (Hida, 1967).

Relation to temperature and salinity

It is found in warmer waters at about 26.61°C and at the salinity value of 32.99 °/oo (Table 10) by Hida (1967).

IX POLYNEMUS MICROSTOMA BLEEKER

IDENTITY

Synonyms

Polynemus microstoma Bleecker 1851
Weber and de Beaufort 1922
Herre 1953
Rajapandian and Murthy 1966

Polynemus plebejus Gunther 1860

Trichidion microstoma Bleeker 1878

Polynemus zophomus Jordan and McGregor 1906
Weber 1913

Polydactylus zophomus Jordan and Seale (1906) 1907
Jordan and Richardson (1907) 1908
Seale 1910

Polydactylus microstoma Herre 1934

Description

D^1. VIII; D^2. I, 13-14; P. 2.13+5; V. I, 5; A. II-III, 12-13; L.l.47-50; L.tr. $\frac{5-6}{10-12}$.

Length of the head and height of the body about 4 times in total length. Villiform teeth on jaws and palatines, no teeth on vomer. First two pectoral rays undivided, upper longest free filament reaches the middle of ventrals. A black shoulder blotch at the beginning of the lateral line(Pl.Fig.1).

DISTRIBUTION

South east coast of India, Indonesian islands, Formosa, Philippines, Penang and New Guinea.

There is no information on the distribution at the different stages of life, bionomics and life history, adult history and exploitation of this species.

X POLYNEMUS SEXFILIS CUV. & VAL.

IDENTITY

Common names

India	Tamil	...	Kala
Ceylon	Sinhalese	...	Gatha

Synonyms

Polynemus sexfilis Cuvier and Valenciennes 1831
Day 1878-1888
Tennet 1933
Munro 1955

Polydactylus sexfilis Deraniyagala 1933
Herre 1935
Fowler 1938, 1949
Schultz 1943

Polynemus sexfilis Merdis 1954

Description

D^1. VIII; D^2. I, 12-13; P. 15+6; V. I, 5; A. III, 11-12; L.l.46; L.tr. $\frac{5}{1}$.
$\frac{}{10}$

Length of head $4\frac{1}{4}$ and height of the body $4\frac{1}{2}$ of the total length. Eye diameter $4\frac{1}{2}$ in head length. Villiform teeth on the jaws, vomer and apaltines. Pectoral rays unbranched, the free rays reach beyond the end of ventral. Caudal deeply forked. Air bladder large. Golden colour, pectoral black and no shoulder blotch.

XI CONCLUSION

In this review an attempt is made to furnish information on the present position of the fishery of polynemids and our knowledge on the biology of the component species. It is surprising to note that no attempt has been made to acquire the basic information pertaining to the life histories and aspects of biology as the size at first sexual maturity, sex ratio, age and growth on most of the species on record; whatever meagre information is available on these subjects refers only to a few species.

In the taxonomy it is seen that most of the workers have followed the descriptions of Day (1878) and also to some extent those of Weber and de Beaufort (1922) in identifying the species. The number and size of the free pectoral filaments is taken as the main distinguishing character of the species and hardly any weight seems to have been given to other characters such as presence or absence of air bladder etc.

Hora (1925) recognises a new subspecies Polynemus sextarius var. mullani (Hora) which according to him possesses all the characters of P. sextarius but differs from it in having seven free pectoral filaments on both the sides. Studying the skeletal characters, Marathe and Bal (1958) observed that P. heptadactylus with seven free pectoral filaments on either side, P. sextarius with six free filaments on both the sides and P. sextarius var. mullani with six pectoral filaments on one side and seven on the other, do not show any skeletal differences.

Day (1878) has mentioned that the air bladder is absent in P. heptadactylus whereas Hora (1925) has noticed it in a greatly reduced form in young individuals. Nayak (1965) has found a large air bladder in this species. Hora has also noted that the air bladder in P. sextarius which is described by Day as 'small and simple', gets reduced with the growth of fish; at the same time he refers to two specimens, one from Madras, used by him for the figure in Fishes of India and the other from Bombay in both of which the air bladder is well-developed and

and extending as far back as the commencement of the anal fin. Hida (1967) refers to a large number of polynemids (94.6% of 564 individuals) with seven free pectoral filaments and a large air bladder as Polydactylus sextarius var. mullani (Hora). It appears that because of the presence of a large air bladder, this must have been considered it to be P. sextarius and because of seven free pectoral fins instead of six, grouped it as variety mullani. It is felt that because of the presence of seven free pectoral filaments on either side in almost all the individuals and also the record of air bladder in this species by Hora (1925) and Nayak (1965), such specimens may rightly be identified as P. heptadactylus C.& V.

As mentioned earlier, the identification of polynemid species has mainly been based on the number and extent of free pectoral filaments. But it may be pointed out that apart from the new subspecies, P. sextarius var. mullani, there are also other species like E. tetradactylum (Hora, 1925) and P. xanthonemus (Hida, 1967) wherein the counts of the free pectoral filaments on either side are subject to great variation. Are all these to be regarded as new sub species or new varieties because of their difference in the number of pectoral filaments as has been shown in the subspecies P. sextarius var. mullani? Further, the information on the occurrence or otherwise of the air bladder and its nature in some of the species is incomplete. These factors along with the recent findings of variation in the nature of hermaphroditism in some of the polynemids sometimes render the identification of even the abundantly available species very difficult. Hence, a reinvestigation of the taxonomy of the Indian polynemids and preparation of a suitable key to differentiate the species and subspecies is very essential.

It has been reasoned that P. sextarius var. mullani of Hida (1967) most probably is no other than P. heptadactylus described by Kagwade (1968a). Hida is of the opinion that this subspecies undergoes protandrous change through a juvenile-hermaphrodite-female change whereas Kagwade has described it as a synchronous hermaphrodite. If the species mentioned by these two authors are one and the same, there appears to be some controversy regarding the nature of hermaphroditism in this species.

Hermaphroditism is observed in seven out of nine species and one subspecies of polynemids in India. Records also show the occurrence

of this phenomenon in one more species of this family, Galeoides decadactylus of West Africa. In Pentanemus quinquarius the occurrence of hermaphroditism has been reported as abnormal (Longhurst, 19[illegible]). In all these species there is a close similarity in the arrangement of the two component parts of the ovotestes wherein the ovarian and testicular parts run end to end, from anterior to posterior; the testicular parts face each other on the inner side. These findings support the doubt whether the occurrence of hermaphroditism is a character which may be a common family trait (Kagwade, 1969a).

When this trait is found to be so common amongst the different members, leading one to believe that the hermaphrodites are normally functional, it is necessary to gain more knowledge on the reproductive behaviour of these individuals. Since no evidence of sex reversal is indicated by any one in the species mentioned, it is desired to find out whether it is the protandrous or synchronous hermaphroditism that is prevailing in the different species. It may be necessary to point out that in practice, it is very difficult to classify the testes according to the maturity stages. At times even the presence of running ripe males is not a definite indication of spawning, as they may be in this condition for some time even in the non-spawning period also. Hence, it would be more appropriate to study the changes in the development in the two component parts of an ovotestis histologically and find out whether the liberation of the sex elements, ova and sperms, is simultaneous or at different times.

The maximum size to which the polynemids grow varies greatly with the species. Majority of them grow to about 15-25 cm in length. The West African species P. quinquarius and G. decadactylus grow to about half a meter or slightly more and in the Indo-Pacific waters two more species, E. tetradactylum and P. indicus grow to over a meter. The comparative study of the ova diameter in the three species, E. tetradactylum, P. indicus and P. heptadactylus presented in Table 1 gives a general impression that the diameter changes involved during the process of maturation in these species are almost the same. However, the diameter ranges of the oil globules in the mature ova are found to differ from species to species and this may help in the identification of the planktonic eggs to some extent.

Table 2 shows the maximum length so far recorded for the different species and the size at first sexual maturity either already known or speculated. From this it is seen that E. tetradactylum which is supposed to grow to 180 cm in length (Day, 1878), is presumed to attain maturity when it grows to even less than $\frac{1}{4}$ of this length; P. indicus, the maximum size of which recorded is 142 cm (Mohamed, 1955) attains maturity when it grows to over $\frac{1}{2}$ of this length. P. paradiseus and P. heptadactylus attain maturity when they grow nearly to $\frac{1}{2}$ the length of their maximum length. P. xanthonemus for which the maximum length is not available on record, appears to mature at about 10 cm in standard length whereas in P. plebeius the size at first maturity is not known. The attainment of sexual maturity in relation to the maximum size, naturally differs from species to species, but in the case of E. tetradactylum the size of first maturity appears too small in comparison with other species about which we have detailed information.

Polynemids with the exception of P. sextarius which is found by Mookerjee et al (1946) to feed on even algae, are carnivores, feeding on a variety of organisms from all environments. None of the species studied so far shows any tendency towards selectivity to any particular food organism in the environment which they inhabit. E. tetradactylum and P. heptadactylus are known to exhibit cannibalistic tendencies. None of the species studied so far seem clearly to indicate selectivity and preference to any particular food organisms. Crustaceans dominated in the food of all the species. However, with growth, these fishes develop more and more piscivorous habits. When young, their pelagic habit is noted by the presence of planktonic organisms like copepods, amphipods and Lucifer sp. in the food; during the adult stage their column feeding is indicated by the presence in their diet of free swimming crabs, penaeid and carid prawns and a number of teleosts from the upper layers of waters and their occasional bottom feeding habit is also noted by the presence of crabs and Squilla sp. from the muddy bottom.

The migratory habits of this group of fishes has hardly received any attention to trace out their movements especially from offshore to inshore waters or vice versa. Tagging experiments if conducted, may throw some light not only on their movements but also about their biological behaviour, especially with reference to spawning, and racial differences, if any.

Studies on the embryonic and larval development are limited to hardly 2-3 species. It is desired that such studies should be extended to other species also.

The scale reading has proved to be a successful method in assessing the age of P. indicus and P. heptadactylus. It is hoped that if this method is applied to other species, it would add to our knowledge on the growth of those species.

A trend towards decline in the polynemid landings noticed in the past one decade or more has been a matter of great concern to the fishing industry. In the past 18 years from 1951 to 1968, the minimum and the maximum of the annual landings were 0.8 and 14.5 thousand metric tons respectively with an average of 4.8 thousand metric tons. From 1962 onwards, the landings have been below the annual average.

The trawl catch analysis for P. indicus ('Dara') in the bull trawlers of the commercial enterprise of the New India Fisheries Co. Ltd., has brought forward some points (Kagwade, 1965). The analysis of the catch for this species in the 8 year period 1956-'63 has shown a steady decline after 1959. In the Bombay-Saurashtra waters, Dwarka has proved to be the best region and the season for this fishery is November to May with the maximum catch during November to March. It is found that after 1959, the fishery was concentrated in the Kutch region where the catch per return for this species is much less than that in Dwarka. This resulted in Dwarka being not adequately exploited, especially during the season. It is also pointed out by Kagwade that whenever Dwarka grounds were touched during the season for 'Dara' fishery, the catch rates were high, viz., areas 'K' yielded 169.37 kg per hour in April 1961 and 199.99 kg in April 1962; 'M' 100.90 kg in January 1962 and 194.68 kg in February 1963; 'N' 261.09 kg in January 1960, 194.36 kg in February 1960, 141.90 kg in February 1961 and 245.64 kg in December 1961. Thus the low catches of 'Dara' in the trawler landings since 1959 appears to be due, at least partially, to inadequate exploitation of its best grounds. As a matter of fact since 1963, hardly any regular fishing is going on by any trawlers either commercial or exploratory in the rich grounds of Dwarka or even Kutch which is the second best region. The interest of the New India Fisheries Co., the only large commercial concern in Bombay, is now

mainly focussed on the fishing of prawns which earn an attractive foreign exchange with the result that the exploitation of other demersal fisheries is getting little attention.

Coming to the inshore fishery of polynemids, especially 'Dara' Jayaraman et al (1959) in the Bombay region, have reported a fall in the catch from 462 'Dara' per sailing vessel in 1952-'53 to 124 in 1953-'54. Later, Banerji (1969) has stated that in the inshore waters of Gujarat, the polynemid catch has declined from 4,572 tonnes in 1960 to only about 237 tonnes in 1967 and the catch per 1000 man hours was reduced from 218 kg to 13 kg.

The catch trends of the polynemid fishery in the north western region thus clearly indicate a tremendous reduction in the catch per unit of effort in the inshore fishery. However, it is difficult to attribute this fall to overfishing. It is a fact that the fishing effort has increased with the introduction of a larger number of mechanized boats in the Bombay-Saurashtra coast. We need more information on the population structure and its relation to fishing effort. In this connection mention may be made of two important aspects of fishing. In the first place it may be remembered that the offshore catches of P. indicus ('Dara') consists of juveniles called 'Chelna', the removal of which in large numbers will undoubtedly result in the diminution of stocks for they are not allowed to grow to adult stage and spawn so that the rate of recruitment may be kept up adequately high. Secondly, the inshore catches mostly consist of adults in advanced stages of maturity. The removal of these also before the spawning period, is detrimental to the replenishment of the stocks. It is felt that some measures will have to be introduced and the fishing of the 'Chelna' as also the adults before spawning be regulated.

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REFERENCES

Anonymous 1951. Report on the Marketing of fish in the Indian Union. Second Edition (Agricultural Marketing in India), Marketing Ser.No.65.

Anonymous 1964. FAO year book of fishery statistics, 18.

Anonymous 1966. FAO year book of fishery statistics, 22.

Anonymous 1967. FAO year book of fishery statistics, 24.

Bal, D.V., and L.B.Pradhan 1945. First progress report on "Investigations of fish eggs and larvae from Bombay waters" 1944-45, Bombay.

Bal, D.V., and L.B.Pradhan 1946. Second progress report on "Investigations of fish eggs and larvae from Bombay waters" 1945-46, Bombay.

Bapat, S.V., and D.V.Bal 1950. Occurrence of fish larvae and post larvae in Bombay waters during 1948-49. Proc. Indian Sci. Congr., Calcutta, 37 (3), (Abstracts): 255.

Bapat, S.V., and D.V.Bal 1952. The food of some young fishes from Bombay Proc. Indian Acad. Sci. 35(2) B: 78-92.

Banerji, S.K. 1969. Is there overfishing in Indian waters? Indian Farming, 19, No.9: 57-58

Berg, L.S., 1940. Classification of fishes, both recent and fossil. English and Russian, Edwards Brothers, Inc. Ann. Arbor, Michigan, U.S.A. 304 and 470.

Bhatt, Y.M., M.N.Kutty, K.V.Subba Rao and D.M.Punwani 1964. "Ghol-Dara" fishery off Bedi Port in the Gulf of Kutch. Indian J. Fish. 11 A (1): 135-156.

Chacko, P.I., 1949. Fish and fisheries of Muthupet Saline Swamp, Tanjore District. Proc. Indian Sci. Congr., Calcutta, 36 (3), Abstracts: 166.

Chacko, P.I. 1949. Food and feeding habits of the fishes of the Gulf of Mannar. Proc. Indian Acad. Sci. (B), 29 : 83-97.

Chaudhuri, B.L. 1917. Fauna of the Chilka Lake : Fish, Part III, Mem. Indian Mus., 5 (6): 491-508.

Chopra, B.N. 1951. Handbook of Indian fisheries, 3rd Meeting of Indo-Pacif. Fish. Coun., Madras, Government of India, Ministry of Food and Agriculture.

David, A. 1954. A preliminary survey of the fish and fisheries of a five-mile stretch of the Hooghly River near Barrackpore, Indian J. Fish., 1 : 231-250.

Day, F. 1878. The Fishes of India 2 Vols. Reprinted 1958, William Dawson & Sons Ltd., London.

Deshpande, S.D. 1962. An account of 'Dara' (Polydactylus indicus Shaw) fishery of the Bombay coast with particular reference to the fishing method by bottom-drift nets. Indo-Pacif. Fish. Coun., C 62, Tech 26 10th Session, Seoul, Korea, 1-20.

Fowler, H.W. 1949. Fishes of Oceania - Supplement 3. Memoirs of the Bernice P. Bishop Museum, 12 No.2 : 72.

Gokhale, S.V. 1957. Operation of the Dol net off the Saurashtra Coast. J. Bombay Nat. Hist. Soc., 54 (3) : 714-25.

Gupta, M.V. 1968. Observations on the fecundity of Polynemus paradiseus Linn. from the estuarine system. Proc. Nat. Inst. India, 34 (B), No.6 : 330-345

Herre, A.W. 1953. Check list of Philippine fishes. Fish and Wildlife Service, U.S. dept. Interior Res. Rep. 20 : 238-240.

Hida, T.S. 1967. The distribution and biology of Polynemids caught by bottom trawling in Indian Seas by the R/V Anton Bruun, 1963. J. Mar. biol. Ass. India, 9 (2) : 281-299.

Hora, S.L. 1925. Notes on fishes in the Indian Museum. Rec. Indian Mus., 27 : 453-469.

Irvine, F.R. 1947. The Fishes and Fisheries of the Gold Coast 200- 202: The Crown Agents for the Colonies, 4 Millbank, London.

Jayaraman, R., and S.S. Gogate 1957. Salinity and temperature variation in the surface waters of the Arabian Sea off the Bombay and Saurashtra coasts. Proc. Indian Acad. Sci., 45 (B) No. 4 : 152-164.

Jayaraman, R., G. Seshappa, K.H. Mohamed and S.V. Bapat 1959. Observations on the trawl - fisheries of the Bombay and Saurashtra waters, 1949 - 50 to 1954 - 55. Indian J. Fish. 6 (1) : 58-144.

Jones, S., and P.M.G. Menon 1953. Notes on the breeding habits and developmental stages of some estuarine fishes. J. Zool. Soc. of India, 5 (2) : 255-267.

Jones, S., and K.H. Sujansingani 1954. Fish and fisheries of the Chilka Lake with statistics of fish catches for the year 1948-50. Indian J. Fish., 1 : 256-343.

Jordon, D.S. 1923. A classification of fishes including families and genera as far as known, Stanford Uni. Publ. Biol. Sci., III, No. 2, 178.

Kagwade, P.V. 1965. Polydactylus indicus (Shaw) in the landings by the bull trawlers operating inthe Bombay and Saurashtra waters during 1956-63. Indian J. Fish., 12(2) : (in press).

Kagwade, P.V. 1968 a. Polynemid fishery resources of India. I.C.A.R. symposium on the living resources seas around India (Abstract appeared in Adv. Abstr. Contr. Fish. Aquat. Sci. India, 2 (4) :88.

Kagwade, P.V. 1968 b. The fishery of Polynemus heptadactylus Cuv. and Val. in India. I.P.F.C. Proc. 13th Sess. pt. 3, Brisbane, Australia. Preprint IPFC/C 68/Sym 27 : 21 pp.

Kagwade, P.V. 1968 c. Hermaphroditism in a teleost, Polynemus heptadactylus Cuv. & Val. (Manuscript)

Kagwade, P.V. 1968 d. The estimation of age and growth of Polynemus heptadactylus Cuv. & Val. by means of scales and otoliths. (Manuscript)

Kagwade, P.V. 1969 a. Hermaphroditism in Polydactylus indicus (Shaw). J. Mar. Biol. Ass. India, 10 (2): (in press)

Kagwade, P.V. 1969 b. The estimation of age and growth of Polynemus heptadactylus Cuv. & Val. by length frequency distribution (Manuscript)

Kagwade, P.V. 1969 c. Maturation and spawning in Polynemus heptadaotylus Cuv. & Val. (Manuscript).

Kagwade,P.V. 1969 d. Growth characteristics of Polynemus heptadactylus Cuv. & Val. (Manuscript).

Kagwade, P.V. 1969 e. Growth parameters and age composition of the commercial catches of Polynemus heptadactylus Cuv. & Val. (Manuscript)

Karandikar, K.R., and V.C. Palekar 1950. Studies on the ovaries of Polynemus tetradactylus (Shaw) in relation to its spawning habits. J. Univ. Bombay, 19(3):21.

Karekar, P.S., and D.V. Bal 1958. The food and feeding habits of Polynemus indicus (Shaw) Indian J. Fish. 5(1):77-94.

Karekar, P.S., and D.V. Bal 1960. A study on maturity and spawning of Polydactylus indicus (Shaw). Indian J. Fish. 7 (1): 147-164.

Klawe, W.L., and F.G. Alverson 1964. Occurrence of two species of young threadfin, Polydactylus opercularis and P. approximans, in the offshore waters of the eastern tropical Pacific Ocean. Pacific Science, 18, (2): 166-173.

Kuthalingam, M.D.K. 1960. Studies on the life-history and feeding habits of the threadfin, Polynemus indicus (Shaw). J. Zool. Soc. India, 12 (2) : 191-200.

Longhurst, A.R. 1965. The biology of West African polynemid fishes. J. Cons. perm. int. Explor. Mer. 30 (1) : 58-74.

Malhotra, J.C. 1953. The food and the feeding habits of the so-called Indian Salmon, Eleutheronema tetradactylum (Shaw). J. Zool. Soc. India, 5 : 139-52.

Marathe, V.B. 1958. A brief comparative account of the axial skeleton of six polynemids from Bombay waters. J. Univ. Bombay, 26 (B) : 139-151.

Meek, S.E., and S.F. Hilderbrand 1923. The marine fishes of Panama. Field Museum of Natural History Publication No. 215, Zool. Ser. 15, pt. I : 288-292.

Mendis, A.S. 1954. Fishes of Ceylon. Published by the Fisheries Research Station, Ceylon.

Misra, K.S. 1959. An aid to the identification of the common commercial fishes of India and Pakistan. Rec. Indian Mus., 57 (1-4) : 1-320.

Mohamed, K.H. 1955. Preliminary observations on the biology and fisheries of the thread-fin, Polydactylus indicus Shaw in the Bombay and Saurashtra waters. Indian J. Fish. 2 : 164-179.

Mookerjee, H.K., D.N. Ganguly and T.C. Mazumdar 1946. On the food of estuarine fish of Bengal. Sci. & Cult., 11(16) : 564-65.

Munro, I.S.R. 1955. The marine and fresh water fishes of Ceylon. 96-98. Published for the Dep. Ext. Affairs, Canberra.

Munro, I.S.R. 1958. The fishes of the New Guinea Region. Papua and New Guinea Agric. Journ., 10, No. 4 : 157. Issued by Dept. of Agric., Stock and Fisheries, Port Moresby.

Myers, G.S. 1936. A new Polynemid fish collected in the Sadong River, Sarawak, by Dr. William T. Hornaday, with notes on the genera of Polynemidae. J. Washington Acad. Sci., 26 (9) : 376-382.

Nayak, P.D. 1959 a. Some aspects of the fishery and biology of Polydactylus indicus Shaw. Indian J. Fish. 6 (2) : 280-297

Nayak, P.D. 1959 b. Occurrence of hermaphroditism in Polynemus heptadactylus Cuv. & Val. J. Mar. biol. Ass. India, 1(2) : 257-259

Nayak, P.D. 1965. Studies on the biology and fishery of Polynemus heptadactylus Cuv. & Val. Thesis for Ph. D. degree of the University of Bombay.

Patnaik, S. 1967. Hermaphroditism in the Indian salmon Eleutheronema tetradactylum (Shaw). Curr. Sci., 36 (19) : 525.

Pillay, T.V.R., and K.K. Ghosh 1962. The bag net fishery of the Hooghly-Matlah estuarine system (West Bengal). Indian J. Fish. 9 A (1) : 71-99.

Rao, K. Virabhadra, K. Dorairaj, P.V. Kagwade and D.M. Punwani 1968. Results of the exploratory fishing operations of the Government of India vessels at Bombay base for the period 1961-'67. I.P.F.C. Proc. 13th Sess. pt. 3, Brisbane, Australia. Preprint IPFC/C68/ Sym 28 : 43 pp.

Ravish, C. 1962. A preliminary account of the distribution and abundance of fish larvae in the Hooghly estuary. Indian J. Fish., 9 A (1) : 48-70.

Sarojini, K.K. and J.C. Malhotra 1952. The larval development of the so-called Indian salmon, Eleutheronema tetradactylum (Shaw). J. Zool. Soc. India, 4, (1) : 63-72.

Schultz, L.P., E.S. Herald, E.A. Lachner, A.D. Welander and L.P. Woods 1953. Fishes of the Marshall and Marianas Islands United States National Museum, Bull. 202, 1 : 323. Smithsonian Institution, Washington, D.C.

Smith, J.L.B. 1949. The Sea fishes of Southern Africa : Central News Agency Ltd., South Africa.

Venkataraman, G. 1960. Studies on the food and feeding relationships of the inshore fishes off Calicut on the Malabar coast, Indian J. Fish., 7 (2) : 275-306.

Weber, M. and L.F. de Beaufort 1922. The Fishes of the Indo-Australian Archipelago. 4, 196-218, E.J. Brill Ltd. Leiden (Holland).

Table 1

Maturity key for E. tetradactylum, P.indicus and P.heptadactylus

Maturity stage	E.tetradactylum	P.indicus	P.heptadactylus
Immature	Ovary small, narrow thread-like in the beginning and getting slightly thicker later on; ova invisible to the naked eye but under the microscope transparent with a distinct necleus in the centre; ova measure in diameter up to -		
	0.40 mm	0.30 mm	0.32 mm
Maturing	Ovary getting enlarged and yellow in colour; eggs are granular and visible to the naked eye; ova yellow and opaque because of the yolk deposition in the cytoplasm; ova measure -		
	0.45-0.68 mm	0.31-0.62 mm	0.33-0.64 mm
Mature	Ovary full and light yellow in colour; this is the oozing stage and the ova are liberated with the slightest pressure; ripe ova are completely transparent with a single oil globule; ova size range -		
	0.70-1.00 mm	0.63-1.10 mm	0.65-1.04 mm
	and the size of the oil globules range -		
	0.25-0.3 mm	0.26-0.40 mm	0.20-0.3 mm
Spent	Ovary shrunken, flaccid and reddish in colour; innumerable small immature ova with a few large degenerating residual ones		

Table 2

Relationship between the maximum size and the size at first sexual maturity in different polynemid species

Species	Maximum size on record (total length in cm)	Size at first sexual maturity (cm)	Author
E.tetradactylum	180	36-39* (total length)	--
P.plebeius	45	..	--
P.[illegible]	25	..	--
P.indicus	142	80 (std. length)	Karekar and Bal (1960)
P.sexfilis	19	..	--
P.[illegible]	24	13.5 ♂ (Total 16.0 ♀ length)	Gupta (1959)
P.heptadactylus	30	12.8 ♂ (furcal 13.3 ♀ length)	Kagwade (1963)

*This length is only tentative till confirmed by further detailed studies.

For P.sexfilis and P.xanthonemus no data available

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Table 3

Estimated number of ova and fish length in P.indicus and P.heptadactylus

Species	Author	Fish length (cm)	No. of ova
P.indicus	Karekar and Bal (1960)	80.1.	3,394,945
	,,	80.1	219,643
	,,	80.5	5[illegible],382
	,,	84.2	3[illegible],005
	,,	84.2	291,288
	,,	84.2	1,92[illegible],[illegible]75
	,,	84.2	2[illegible],065
	,,	84.2	1,4[illegible],[illegible]94
	,,	84.3	11[illegible],[illegible]61
	,,	84.7	3,706,543

Table 3 (contd.)

Species	Author	Fish length (cm)	No. of ova
P.heptadactylus	Kagwade (1969)	17.5	61,943
	,,	17.5	39,338
	,,	17.5	20,914
	,,	16.0	12,430
	,,	16.0	9,204
	,,	16.0	4,972
	,,	16.0	16,692
	,,	15.3	6,400
	,,	15.3	25,815
	,,	14.5	37,092
	,,	14.5	8,857

Table 4

The peak spawning periods of some of the polynemid fishes

Species	Peak spawning	Locality	Author
E.tetradactylum	Jan.-Apr. and Jul.-Sep.	Bombay waters	Karandikar and Palekar (1950)
P.indicus	Apr.-Jun. and Oct.-Dec.	Bombay-Saurashtra waters	Nayak (1959)
	Oct.-Nov.	Madras waters	Kuthalingam (1960)
P.paradiseus	Mar.-Jun.	Hooghly River	David (1954)
	May -Jun.	Hooghly & Rupnarayan estuaries	Gupta (1968)
P.heptadactylus	Mar.-Jun. and Aug.-Nov.	Bombay Saurashtra waters	Kagwade (1969 c)

Table 5

Sex composition in polynemid fishes

Species/ Author	Total No. of fish	No. of hermaphrodites (%)	No. of males (%)	No. of females (%)
E.tetradactylum Patnaik (1967)	--	2	--	--
P.plebeius Hida (1967)	10	1(10%)	1(10%)	8(80%)
P.indicus Kagwade (CMFRI Scientific Report 1969)	83	33(39.76)	16(19.28)	34(40.96)
P.sextarius Hida (1967)	140	112(80.00)	1(0.71)	27(19.29)
P.sextarius var. mullani Hida (1967)	401	231(57.61)	1(0.25)	169(42.14)
P.xanthonemus Hida (1967)	109	18(16.51)	49(44.96)	42(38.53)
P.heptadactylus Kagwade (1968c)	858	145(16.90)	197(22.96)	516(60.14)
P.quinquarius* Longhurst (1965)	25,292	2(0.01)	11,371(44.96)	13,921(55.04)
G.decadactylus* Longhurst (1965)	25,357	5,634(22.22)	16,160(63.73)	3,557(14.03)

*Numbers under different sexes recalculated.

Table 6

Country-wise annual landings of polynemids in thousand metric tons during 1962 to 1967

Country	1962	1963	1964	1965	1966	1967
Ghana	0.7	2.9	2.3	6.3	7.7	0.8
Ivory Coast	-	-	1.0	1.5	1.7	1.3
India	2.8	4.4	2.2	1.7	4.6	2.6
China	1.8	1.9	3.5	2.2	2.0	2.2
Philippines	-	0.2	0.4	0.1	0.1	ø*
Australia	0.1	0.1	0.1	0.1	0.1	0.1

*catch negligible

Table 7

Regional catch per hour returns (in kg) of P.indicus from 1950 to 1963.

Year	Vessels	Bombay	Cambay	Veraval	Porbundar	Dwarka	Kutch
1950-51	'M.T.Ashok'* & 'M.T.Pratap'	5.8	10.1	4.7	---- No fishing -------		
1951-52	Do	4.2	8.7	0.6	0.5	29.2	Do
1952-53	Do	2.9	4.0	3.0	0.0	21.4	Do
1953-54	Do	4.8	5.2	0.3	1.5	195.0	Do
1954-55	Do	0.0	3.9	4.7	2.5	322.5	Do
1955-56	Do	1.0	7.3	1.7	0.3	269.6	Do
1956-57	Do	0.5	0.0	0.0	3.3	187.6	Do
1956	'Arnalla'-'Paj'** & 'Satpati'-'Pilotan'	1.2	0.2	0.0	3.4	145.0	Do
1957	Do	0.45	0.9	0.1	1.0	124.2	88.0
1958	Do	0.9	0.3	1.6	3.7	78.3	0.5
1959	Do	0.0	0.6	0.2	0.5	112.7	8.0
1960	Do	5.5	1.3	0.8	0.5	93.2	15.1
1961	Do	0.0	0.2	1.8	0.6	47.8	19.3
1962	Do	0.0	0.3	0.2	0.6	25.6	16.4
1963	Do	0.0	1.1	2.3	1.0	10.0	15.2

* Nayak 1959

** Kagwade 1965

Note: 1950-51 to 1952-'53 - Otter-trawling
1953-54 to 1963 - Bull-trawling

Table 8

Fishery seasons for polynemid fishes

Fish	Locality	Fishery season	Peak season	Author
E. tetradactylum	Bombay waters	Jan.-Apr. & Jul.-Sep.	--	Karandikar & Palekar (1950)
	Hooghly and Matlah estuarine system	Aug.-Sept	--	Pillay & Ghosh(1962)
P. indicus	Satpati fishing village	Feb.-May	--	Mohamed (1955)
		Dec.-May & Aug.-Sep.	Mar.-May	Deshpande (1962)
	Gulf of Kutch	Feb.-May	--	Deshpande (1962)
		Mar.-May	--	Bhatt et al (1964)
	Trawling grounds of Bombay and Saurashtra waters	Nov.-May	--	Kagwade (1965)
			Nov.-Mar	Nayak (1959 a)
	Hooghly and Matlah estuarine system	any time of the year	--	Pillay & Ghosh(1962)
P. paradiseus	Hooghly and Matlah estuarine system	all thro' the year	May-Oct.	Pillay & Ghosh(1962)
P. heptadactylus	Bombay and Saurashtra waters	all thro' the year	no marked peak at any time of the year	Kagwade (1968 b)

Table 9

Depth-range in which the different polynemid species are recorded

Species	Depth-range in metres	Author
P.plebeius	23-122	Hida (1967)
P.indicus	9-70	Deshpande (1962) & Rao et al (1968)
P.sextarius	19-73	Hida (1967)
P.sextarius var.mullani	18-122	Hida (1967)
P.xanthonemus	19-30	Hida (1967)
P.paradiseus	15-27	Hida (1967)
P.heptadactylus	21-80	Kagwade (1968b)

Table 10

Temperature and salinity data of the stations in the Bay of Bengal and the Arabian Sea from where the polynemid species were recorded by Hida (1967)

Station/ Location	Month	Species	Temperature	Salinity
Bay of Bengal	April'63	P.indicus	26.09-27.82°C	31.94-31.74 °/oo
	Mar-Apr'63	P.sextarius	23.98-26.16°c	32.99-34.00°/oo
	Apr'63	P.xanthonemus	26.61°C	32.99 °/oo
	Mar-Apr'63	P.paradiseus	26.09-27.82°C	26.56-32.60 °/oo
Arabian Sea	Nov-Dec'63	P.plebeius	23.54-25.40°C	36.33-36.71°/oo
	Nov'63	P.indicus	25.93-25.56°C	36.10-36.12 °/oo
	Nov-Dec'63	P.sextarius var. mullani	22.36-27.97°C	36.01-36.71 °/oo

Table 11

Growth characteristis of P.heptadactylus

Age	Length at 1_1	Growth characteristic	Average growth characteristic	Period
I	-	-	-	
II	83	35.939	35.939	juvenile stage
III	128	26.880	25.026	sexual maturity
IV	158	27.334		
V	188	23.312		
VI	213	22.578		
VII	237	17.301	17.320	old age
VIII	255	17.340		